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REPORT ON EXPERIMENTAL WORK DEALING WITH THE

PRECOOLING

TRANSIT REFRIGERATION

RIPENING

OF CALIFORNIA BARTLETT PEARS DURING THE

1941 SEASON

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(A cooperative investigation by the Bureau of Plant Industry, U. S. Department of Agriculture; the Division of Pomology, California Agricultural Experiment Station; and the California Tree Fruit Agreement.)

By

W. T. Pentzer, physiologist, C. O. Bratley, pathologist, A. Lloyd Ryall, associate pomologist, and James S. Wiant, associate pathologist, Division of Fruit and Vegetable Crops and Diseases, Bureau Plant Industry, U. S. Department of Agriculture.

F. W. Allen, associate pomologist, H. T. Hartmann, research assistant, and D. S. Glenn, research assistant, Division of Pomology, California Agricultural Experimental Station.

C. N. McClanahan, C. N. Ely and Warren G. Tufts, California Tree Fruit Agreement.

INTRODUCTION

Since 1934 the Bartlett pear shipping industry of California, organized under a Federal Marketing Agreement, has worked to improve the marketing of its product. In evaluating the results obtained with controlled shipments, the administrative committees found considerable trade resistance to California Bartletts because of the tendency of the fruit to break down in consuming markets during certain periods. In order to determine the cause of this condition and in an effort to place Bartletts in the hands of the consuming trade in the best possible condition, officials of the California Tree Fruit Agreement were authorized to enter into a cooperative agreement with the Bureau of Plant Industry, United States Department of Agriculture, and the Division of Pomology, California Agricultural Experiment Station to make test shipments of Bartletts during the 1941 season. The object of this research was to determine the amount of precooling required, optimum transit temperatures and the best methods of handling and ripening California Bartletts.

OUTLINE OF TESTS

The general plan agreed upon by the several agencies cooperating in the studies was to ship experimental lots of fruit from the Sacramento Valley, the foothill districts, and Lake and Mendocino counties during the commercial shipping season, selecting boxes of fruit of average size (150's--165's) and of known orchard history for this purpose. Color photographs were made of the fruit as soon as it was packed, and records were taken of its color, soluble solids and pressure test. One box of each test lot was stored for 10 days at Davis at 42° F., approximating refrigerator car temperatures, before ripening. Duplicate boxes from each orchard were loaded in the top layer, doorway stack of the cars which were to receive different amounts of refrigeration, usually differing principally in the time that they were precooled. In non-precooled shipments, test boxes were also loaded in the bottom layer of the stack next to the bunker so that within the same car the effect of low and high transit temperatures on the fruit could be compared. Recording thermometers were packed in the center of duplicate boxes to register the temperature of the fruit from time of loading until time of removal from the car at destination.

Fruit and air temperatures during precooling were taken in the center of boxes throughout the load with electric resistance thermometers that could be read without opening the car. The amount of ice and salt supplied, the time it was added and the operating record of the precooling equipment were noted so that a complete picture of the cooling operation could be reconstructed.

The test fruit was taken to the Bureau of Plant Industry laboratory upon arrival in New York where color photographs were made if any unusual condition was in evidence. The equipment used in taking

photographs and the methods that were followed in California and New York were standardized to eliminate avoidable differences in color reproduction. The pears were inspected for firmness, color and general appearance before they were transferred to ripening rooms where some were held at 66° to 68° or at about the middle of the temperature range of 60° to 70° considered to be optimum for most varieties of pears by several previously reported investigations. 1/ The remainder of the test fruit was ripened at higher temperatures of 81° to 83°, such as are commonly experienced on fruit stands during warm summer months. The humidities were relatively high, about 80 percent at both temperatures. When the fruit was ripe, notes were taken on its appearance and the amount of decay, scald, breakdown, and shriveling that was in evidence. Flavor was determined by a tasting jury who scored a representative sample of pears from each lot. The evenness of ripening, the days required to ripen and the length of time the fruit remained marketable after being ripened were also recorded.

In planning the studies, information on the following points was sought:

1. The relationship between the stage of maturity of the fruit when picked and its flavor and appearance on the market.

2. The relationship between precooling and transit temperatures on the quality and condition of early, midseason, and late shipments of pears.

3. The amount of precooling that pears usually receive under commercial precooling practices, and its effect on subsequent transit temperatures.

4. The relationship between ripening temperatures and the quality and condition of pears.

A total of 19 test shipments were made for which the precooling period ranged from none at all to as long as 120 hours, and transit refrigeration varied from initial ice only to standard refrigeration (table 1).

1/ Hartman, et al Ore.Agr.Exp.Sta.Bul.228,1927, Ore. Agr.Exp.Sta.Bul.254,1929; Magness, et al U.S.Dept. Agr.Tech. Bul.140,1929; Allen, Calif.Agr.Exp.Sta. Bul.533,1932; Pentzer, et al, U.S.Dept.Agr.Tech. Bul.290,1932; Furlong and Barker, S.African Decid. Exch.Bul.23,1935; Tindale, et al, Jour.Dept.Agr. Vol.36, 1938.

RESULTS

Transit Temperature Studies

Methods of refrigeration and transit temperatures compared in the tests and their effect on appearance of fruit on arrival.

A brief summary of the various shipping tests follow:

Test 1. July 11, Locke, Calif. Car 1 non-precooled, 74°F. when shipped; car 2 precooled to 49°, 1/, both shipped with one reicing in transit.

As indicated in figure 1, during the first few days in transit, the top layer, doorway stack of the precooled car was 15° to 30° cooler than was the same position in the non-precooled shipment. The average transit temperatures were 47° and 57° respectively, but despite the higher temperature in the non-precooled car, the condition of the test fruit from both cars was similar on arrival, being considered slightly too green for best auction display.

Test 2. July 14, Yuba City, Calif. Car 3, non-precooled, shipped standard refrigeration; car 4, precooled to 35°, reiced once in transit; car 5, precooled to 63°, shipped standard refrigeration.

The temperature records of the top layer, doorway stack of these three cars are shown in figure 2. It is quite evident that the small amount of precooling that car 5 received was of no value in lowering its transit temperature, which averaged 56°, the same as non-precooled car 3. Car 4, thoroughly precooled, had a low transit temperature, averaging 43° for the trip. Again in spite of these differences in transit temperatures, there was little difference in the condition of the fruit either upon arrival or after it was ripened. All of the test fruit was considered to be too green for best auction display.

The transit temperatures of the top layer, doorway stack and bottom layer, bunker stack of car 3 are compared in figure 3. Differences as great as 20° existed during the first few days in transit and even upon arrival the fruit was 8° cooler in the bottom layer next to the bunker than it was in the top layer at the doorway. If the fruit had been precooled or if the car had been equipped with fans to circulate air in transit, the temperatures would have been more uniform.

1/ The final precooling temperature referred to was the average of 9 positions in the load whereas the temperatures shown in the figures were from records obtained in the top layer of the doorway stack with recording thermometers.

These curves illustrate the usual wide difference in temperature between the bottom and top layers in non-precooled cars.

Test 3. July 19, Walnut Grove, Calif. Car 6, precooled to 46°, reiced once in transit; car 7, precooled to 30°, reiced twice in transit.

The temperature of the top layer of car 7 rose abruptly after the fruit was removed from the precooling room to the refrigerator car (figure 4), and it continued to rise at a slower rate for the next 7 days in transit, until on arrival it was about 46°, or only slightly lower than in the companion car. This test illustrated the fact that even though the car was exceedingly well cooled, the fruit in the top layer rose to a temperature that the refrigerator car could maintain. Considering the extended precooling which the fruit received, it was probably not necessary to reice the car more than once in transit. The average transit temperatures were 46° for car 6 and 42° for car 7. The test fruit in both cars was reported to be slightly too green for best auction display upon arrival.

Test 4. July 23, Yuba City, Calif. Car 8, precooled to 39°; car 9, precooled to 31°, both reiced once in transit.

The differences in transit temperatures of the top layer, doorway stack of these cars varied from about 10° the first day in transit to less than 5° toward the end of the transit period (figure 5). The average temperature was 50° in car 8 and 43° in car 9. When the fruit was inspected on arrival (table 2) the test lots from car 9 with the low transit temperature were too green for best auction display whereas the fruit from car 8 was of good to excellent color, indicating that in this case extended precooling was not necessary or desirable.

Test 5. July 25, Hood, Calif. Car 10, non-precooled, 550-box load, shipped standard refrigeration with 3 percent salt; car 11, 720-box load precooled to 41° reiced twice in transit.

The non-precooled 550-box load was not as well refrigerated as the precooled 720-box load, having temperatures 35° higher in the top layer at the doorway during the first day in transit and averaging 52° for the transit period as compared to 43° for the heavy load (figure 6). Precooling more than offset the difference in loads and refrigeration in transit. It is interesting to note, however, that again the fruit in the warmer car was more desirable for auction display, indicating that more refrigeration was given the precooled car than was actually needed. The transit temperatures in the bottom layer, bunker stack and top layer, doorway stack of the non-precooled 550-box load are shown in figure 7. As in non-precooled car 3, there was approximately 10° difference in temperature between these two positions in the same car.

Test 6. August 4, Yuba City, Calif. Car 13, precooled to 34°; car 14, precooled to 38°, both shipped with one reicing in transit.

The effect of extended precooling in lowering transit temperatures was brought out clearly in this test (figure 8). Car 13, precooled for about 61 hours, had a temperature in the top layer, doorway stack about 8° lower throughout the entire transit period than in car 14, averaging 38° in the former car as compared to 47° in the latter. However, this proved to be of no apparent value, since the test fruit in the warmer car had a more desirable color on arrival than comparable fruit shipped in the cooler companion car. This is especially interesting because the shipment was made late in the season, when the maturity of the fruit was well advanced.

Test 7. August 7, Lake County, Calif. Car 15, precooled to 47°; car 16, precooled to 31°, both shipped with one reicing in transit.

The effect of long precooling on subsequent transit temperatures was again quite evident (figure 9). Car 15, precooled for only 19½ hours had an average transit temperature of about 45° in the top layer of the doorway stack as compared to 41° in the same position in car 16 which was precooled for 80 hours. The inspection of the test fruit on arrival indicated that car 16 had received more refrigeration than was desirable, for the fruit was considered to be too green for best auction display. Some of the fruit in car 15 was also slightly green.

Test 8. August 11, Placerville, Calif. Car 17, precooled to 49°, shipped standard refrigeration; car 18, precooled to 30°, shipped with initial ice, no reicing in transit.

Well cooled car 18 had temperatures in the top layer of the doorway stack 8° to 15° lower during the first week in transit than in companion car 17 (figure 10). The average transit temperatures were 41° and 47° respectively. The arrival temperature of car 18 was higher than that of car 17 even though the former was far better precooled. This illustrates how unreliable the arrival temperature may be when used as an indication of the temperature to which the fruit has been subjected in transit. It was again found that the fruit in the warmer car was better for auction display than similar fruit shipped in the cooler car.

Summary of tests.

It would appear from these tests, summarized in table 2, that precooling for a long time was not desirable from the standpoint of color for auction display. Non-precooled shipments made during the first week of the pear season, with transit temperatures in the warm part of the car (top layer, doorway stack) averaging as high as 57°, did not arrive too ripe, but in some cases were reported to be somewhat too green in color. Later in the season as well, the warmer car of the pair was generally better so far as the appearance of the test fruit was concerned, even though the comparisons were made in the top layer of the doorway stack, normally a warm part of the load. It should be

emphasized that these results are from only one season's work and that the tests should be carried on for several seasons to establish definitely the refrigeration requirements of pears. It is not known to what extent the ideas of the buying trade may change from year to year or what effect the different growing and shipping conditions may have on the ripening and softening of pears in transit. Continuing to secure color photographs of test lots before and after shipment will help to answer some of these questions.

Effect of transit temperatures on softening of pears in transit.

Several other factors in addition to the appearance of the fruit must, of course, be considered in determining the refrigeration that pears need. The firmness of the fruit upon arrival and the amount that it softens in transit, shown in table 3, is of importance in judging whether or not refrigeration is adequate. In some instances, the fruit softened in transit as much as 3 to 5 pounds by pressure test but even in these cases it was still firm enough upon arrival (15 to 16 pounds pressure test) to be acceptable. In most cases, with transit temperatures of 50° or even a few degrees higher, the softening was so slight as to be of no consequence. The average drop in firmness in transit for all of the test lots was about one pound by pressure test.

Comparable tests made at Davis in which the fruit was held for 10 days at a temperature of 42° also showed negligible changes in firmness. Several lots of fruit softened from 1 to 2 pounds by pressure test but others, due to water loss, showed a corresponding increase in firmness.

Effect of transit temperatures on the flavor of the fruit and evenness of ripening.

It was thought that thorough precooling and subsequent low transit temperatures might have a beneficial effect on the evenness with which the fruit ripened. No differences were found, however, that could be attributed to the refrigeration the pears received. In some cases, the fruit was best from the warm cars; and in other cases, the reverse was true. No correlation was found between transit temperature and flavor or evenness of ripening in fruit ripened at 66° to 68° or in that ripened at higher temperatures of 81° to 83°.

The influence of transit temperature on breakdown.

Breakdown of the flesh of Bartlett pears upon ripening has been a serious defect reported in many shipments of this variety from California. It was thought that well refrigerated shipments might be less subject to this trouble than fruit transported at warmer temperatures. However, as indicated in table 4, this was not borne out by the tests since the amount of breakdown which developed in fruit shipped in the warmer cars of the pairs averaged only about 12 percent as compared to 14 percent in fruit shipped in the companion cars with

lower temperatures. The fruit in each pair of cars was strictly comparable so if there had been any marked influence of precooling or low transit temperature in preventing breakdown it should have been apparent. The above percentages of breakdown are for fruit ripened at 81° to 83°, for, as will be brought out later in the report, breakdown was of little importance when the fruit was ripened at 66° to 68°F.

Precooling Studies

Since the transit temperature of the fruit is controlled largely by the amount of precooling that it receives (see figure 12), considerable attention was given to the precooling of Bartlett pears with the various kinds of equipment used commercially in California. Eighteen precooling tests were made during the course of these investigations, the results of which are summarized in table 5. It will be noticed that generally the fruit averaged in the low 70's at the start of the test. The duration of cooling was the principal factor in reducing the temperature of the fruit. The general results in regard to the time required to cool pears to a given temperature were similar to those found previously by Allen and McKinnon (Calif.Agr.Exp.Sta.Bul. 590, 1935). To precool the fruit until it had an average temperature of 45° to 50° in the center of the boxes throughout the carload required 18 to 24 hours, with air blast temperatures averaging 31° to 38°. To reach average final fruit temperatures of approximately 32° required 61 to 119 hours with air temperatures averaging 28° to 33° for the entire cooling period. As pointed out above, precooling to this extent proved to be of little advantage in these tests, unless perhaps the fruit was to be shipped without reicing in transit. With the exception of car 5, in which the bunker ice was completely exhausted during precooling, air temperatures in the car were fairly low in all precooling tests. They were much lower than were generally obtained in the precooling of plums, grapes and other fruits that give up their heat much more readily to the air passing through the load than do pears which are wrapped and tightly packed in boxes. This means that the cooling rate of the pears was extremely low. The greatest amount of cooling that was obtained was $1\frac{1}{2}$° per hour (car 15 precooled $19\frac{1}{2}$ hours). From the results, it appears that in cars cooled to temperatures in the range of 40° to 50°, a cooling rate of about 1° to $1\frac{1}{2}$° per hour can be expected. When the car was precooled until the fruit reached a temperature of approximately 32° the cooling rate was only 0.4° to 0.9° per hour. The difference in temperature between the fruit and the air used for precooling, and the velocity and direction of the air all affect the cooling rate materially. If the precooling operator used enough ice and salt or mechanical refrigeration so that the air blast temperature was 32° or a few degrees lower, the amount of cooling accomplished was determined generally by the duration of the cooling. This is brought out clearly in figure 11, in which the final average precooling temperature is plotted against the hours cooled. Although the results of the various tests do not fall on the curve, they follow a definite trend that indicates about how long the cooling period would have to be to get any desired temperature.

Referring again to table 5, it is apparent that a considerable amount of salt, ranging from 625 to 1,000 pounds, was needed to maintain low air temperatures during precooling. Ice was melted in amounts varying from about 8,300 to 13,600 pounds per car. The reduction of temperature in heavy loads of pears, usually consisting of 720 boxes, was generally about $2\frac{1}{2}^{\circ}$ for each 1,000 pounds of ice melted. In tests 6, 8, and 9, the amount of cooling was considerably greater than this for some reason as yet unexplained.

Precooling tests with portable fans.

Records obtained in precooling tests on cars 2 and 9 are presented (figures 13 and 14) as examples of precooling with portable propeller fans installed at the top openings of the bulkheads. Car 2 (figure 13) was cooled for approximately 20 hours with air of low temperature obtained by salting the ice frequently. The top layer was cooled more rapidly than other portions of the load. After 14 hours it was about 8° cooler than the bottom layer. In car 9, (figure 14), precooled with similar equipment, the temperatures were more uniform even during the first part of the relatively long cooling period (about 60 hours). Prolonged precooling resulted in fairly uniform temperatures throughout the load. The fruit cooled slowly when it was only a few degrees warmer than the air blast, a condition that prevailed during the last 8 or 10 hours of the precooling test. The bottom layer cooled faster than the top layer in this car probably because in the type of load used a channel was left in the top layer along the center line of the load and there were no boxes in the direct path of the air blast. The air temperatures were low during most of the precooling, salt being added early in an effort to lower the air blast temperature to 32° as soon as possible.

Precooling test with mechanical refrigeration, trackside ammonia coils.

In this test (figure 15), air was blown into the car at the top half of the doorway from a set of coils installed alongside the track. It was returned to the cooling unit through the lower half of the doorway opening. The top layer, receiving the direct benefit of the air blast, cooled much faster than the rest of the load and at the end of 20 hours was about 6° cooler than the car average and about 9° cooler than the middle layer. The middle and bottom layers were similar in temperature throughout the test. Air temperatures could be kept low for only short periods because the coils frosted rapidly and had to be defrosted by turning off the supply of ammonia. Air temperatures averaged 36.8° in this car as compared to 32.9° in car 2. The fruit was cooled to an average temperature of 47° in $19\frac{1}{2}$ hours, or about the same as was obtained with fans and ice in car 2.

Precooling test in refrigerated warehouse.

Although cooling was not so rapid with warehouse precooling as with portable equipment, it was much more uniform (figure 16).

There was only a degree or two difference in temperature between the top, middle, and bottom layers. This illustrates the advantage of having uniform air distribution which was made possible by the proper location of air ducts and the stacking of fruit with ample air spaces around each box. It will be noticed that after 40 hours, the rate of cooling dropped off as the temperature of the fruit came closer to that of the air.

Evaluating effectiveness of precooling.

Length of precooling.

There are several ways to check the precooling job that a carload of pears has received. Records kept by commercial precoolers usually show the number of hours that the equipment has been operated. The precooling tests reported here have shown that about 18 to 24 hours are required to cool pears from initial temperatures of about 75° to final temperatures of 45° to 50° throughout the load. This was true for all of the equipment tested, which included several types of propeller fans and a mechanically refrigerated unit. If the time that the equipment is operated is considered in estimating the cooling accomplished and necessary attention is given to replenishing and salting the ice supply, it will be a more accurate and satisfactory measure of the effectiveness of the cooling than the present method of taking a few superficial temperatures. An approximation of the time required to cool to various temperatures can be obtained from figure 11. In general the cooling rate in heavy loads was from 1° to 1½° per hour when the fruit was cooled to temperatures between 40° and 50°.

Ice meltage.

With equipment that melts ice to precool the fruit, the amount melted is a good basis for estimating the cooling accomplished. Generally the temperature of heavy loads of pears was reduced about 2½° by the meltage of 1,000 pounds of ice. To cool a carload from 75° to a final temperature of 45° required the meltage of about 12,000 pounds of ice. The bunkers of most refrigerator cars hold approximately 10,600 pounds of ice when filled and have a volume equal to about 137 pounds of ice per inch of depth. If the bunkers are filled or their ice levels are recorded at the start and finish of precooling and the ice that is added during precooling is accounted for, total ice meltage and the heat removed can be estimated. The temperature of the fruit at the time of packing can be used as the average starting temperature.

Temperature of the fruit.

If some position in the load could be found where the fruit temperature represents the average of the load and it could be reached with ordinary thermometers, it would provide a convenient way to check car precooling. The temperature of fruit in the top layer of the doorway stack varied 1° to 5° from the average of the load in all of the

tests except in a car which had cold air blown in at the doorway (table 6). In this car it was 13° lower than the average temperature of the load but the temperature of fruit in the top layer of the bunker stack was within about a degree of the car average. It should be pointed out that in making these comparisons the temperature of fruit in the center of the boxes was used, rather than that of fruit in the outside layers, as is usually done. The checking of fruit temperatures in warehouse-cooled cars is a simple matter at the time the fruit is loaded from the warehouse into the refrigerator car.

Comparison of Flavor of Fruit from Different Districts.

On the basis of dessert quality ratings given the different test lots of fruit ripened in New York, the average score for the different shipments harvested during early, mid and late season are shown by districts in table 7. Although the results are considered too meager to be conclusive, they indicate that in both of the ripening temperature ranges (66° to 68°, and 81° to 83°) early shipments of fruit from the Sacramento Valley were regarded as being of somewhat lower quality than those from the other districts. These differences were probably due to differences in maturity. Mid-season shipments of Sacramento Valley fruit when ripened at the higher temperatures which ordinarily prevail in the eastern markets during July and August were also rated slightly lower in quality than those from other districts. However, when these mid-season shipments of Sacramento Valley fruit were ripened at 66°-68°, it was of better quality than the early shipments and compared favorably with that shipped from the other districts two or three weeks later. Late shipments of fruit from the Sacramento River district when ripened at 81° to 83° were slightly superior to early fruit from other districts ripened at these temperatures. When ripened in the lower temperature range the late fruit from all districts was similar in quality. In all instances fruit ripened at temperatures of 66°-68° was of better quality than similar fruit ripened at 81°-83°.

Effect of Maturity upon Quality.

With the exception of fruit from the Sacramento River district, there was little correlation between date of harvest and dessert quality of the ripe fruit as measured by flavor and texture. Bartlett pears from "the River" which were harvested on July 11, and shipped in the first test cars averaged 67 points in flavor score (within the "good" range) when ripe, whereas those harvested on July 25 averaged 82 points (within the "excellent" range). While this difference may not have been highly important commercially, because the pears of the lower score were undoubtedly acceptable to the consumer, they indicate the increase in quality obtained by leaving the fruit on the trees for an additional two weeks. From these results the wisdom of delaying the beginning of the Bartlett harvest on "the River" for 7 to 10 days beyond the usual time is apparent. This was accomplished by grower cooperation through the California Tree Fruit Agreement. If the

harvest had been begun at the normal time the quality of the fruit at that time would have been much lower.

No relationship was found between harvest maturity of the test fruit and the amount of breakdown developed at either of the ripening temperature ranges, nor was there any significant relationship between fruit maturity and the color of the ripe fruit.

Effect of Ripening Temperature Upon Flavor.

The pears ripened at 66° to 68° and at 81° to 83° after arrival at New York were scored for flavor when they reached their most desirable stage of softening. Comparative standards established for rating the flavor of the pears were as follows: 0 - 24, poor; 25 - 49, fair; 50 - 74, good; 75 - 100, excellent. Flavor ratings of the different tasters for each lot were averaged to make the scores recorded in table 8. In all cases the fruit ripened at the lower temperature was equal or better in flavor than comparable fruit ripened at the higher temperature, averaging 75 or "excellent" on the flavor scale as compared to 58 or "good" for the latter fruit. Fruit ripened at the lower temperatures was juicier and had flesh of a more melting consistency than similar fruit ripened at the higher temperatures and its aroma was likewise better.

Results similar to these were obtained with the fruit from each test shipment that was held at Davis at 42° for 10 days and then ripened at 3 to 5 different temperatures which in some cases were as low as 47° and in others as high as 90°. The ripening record on typical lots of fruit held at Davis from the various shipping tests is presented in table 9. The observations and records show clearly the influence of temperature on the development of dessert quality. All samples ripened at 70° were of good appearance and color and had satisfactory to good quality. Comparable samples ripened at 65° were, however, of better texture, somewhat more juicy and in most instances were regarded as being of better flavor. Fruit held at 85° to 90° ripened imperfectly in all cases; the flesh usually remained hard and woody and had either an insipid or an unpalatable acid flavor giving it unacceptable dessert quality. Samples held at 57° and one held at 47° ripened with good marketable appearance and color, but the texture and flavor of the flesh was inferior to comparable lots ripened at 65°.

Effect of Ripening Temperature on the Development of Color and Breakdown and on the Length of Time Required to Ripen the Fruit.

In the ripening tests made in New York, pears ripened at temperatures above 80° did not develop full skin color but instead retained some green, which gave them a dull appearance. Some showed light green blotches around the lenticels and there was considerable variation in color among fruits in the same lot when ripe. On the other hand, the fruit ripened at 66° to 68° generally developed the full deep yellow characteristic of Bartlett pears. When the fruit

had softened to the most desirable stage for eating, the color of each lot was determined by comparison with the standard color chart of the California State Department of Agriculture. Colors, with their numerical designations, shown on this chart are: green - 1, light green - 2, yellowish green - 3, yellow - 4. Colors mid-way between those illustrated on the chart were estimated and recorded. The full yellow Bartlett color was designated as 4-plus. Color designations for each lot are shown in table 10.

The number of days required at each temperature to ripen the fruit to its most acceptable stage for eating is also shown in table 10. Generally, a day longer was required to ripen fruit at 81° to 83° than to ripen similar fruit at 66° to 68°F. More variation in rate of ripening was found at the higher temperature, and certain fruits failed to soften but remained firm until they became broken down or decayed. Neither ripening temperature nor transit temperature had any noticeable effect on the numer of days the fruit remained in marketable condition after it was ripe.

Breakdown was much more prevalent at the higher ripening temperatures, being found in 46 out of 54 lots, whereas it was found in only 3 of the comparable lots ripened in the lower temperature range (table 10). The average amount of breakdown was 11.6 percent at the high ripening temperature as compared with 0.2 percent at the low ripening temperature. The breakdown was not the usual storage type that first affects the core areas in the fruit, but was a surface collapse sometimes extending to the core. Affected pears were usually more prevalent in the center of the packed boxes. The occurrence of most of the breakdown at this location in the box may possibly be accounted for by the higher temperature found there. Thermographs buried in packed boxes held in the 81° to 83° ripening room recorded temperatures from 4° to 6° above that of the air, due to the heat of respiration. Other investigators who observed this condition attributed it in part to the accumulation of toxic volatile substances in the center of the box. 1/

The fruit ripened at Davis likewise showed differences in color and prevalence of breakdown that were associated with ripening temperature. A few samples required one day longer to ripen at 65° than at 70° but those ripened at the lower temperature remained in a little better condition throughout the marketable period, some being considered marketable for one additional day. Fruit held at 85° to 90° required from two to three times the number of days to soften and color as did comparable samples held at either 65° or 70°, (table 9). In most instances the fruit at higher temperatures developed scald and was showing some decay and breakdown either on the surface or at the

1/ Furlong and Barker, Report on ripening tests with S. African pears and plums. Bul. 23, S. Afr.Coop.Decid.Fruit Exch. 1935.

core before it was considered ripe. In no case did it ripen with an attractive yellow color. Samples ripened at temperatures as low as 57° and 47° required approximately twice as long to ripen as those held at 65° and about the same time as those held at 85°.

The results obtained in these investigations show clearly that ripening temperatures of 65° or 66° to 68° are better than lower or higher temperatures resulting in better flavor, texture, color and more uniform, rapid ripening. These findings are in agreement with the results of most of the previously reported work on the ripening of Bartlett pears.

The relationship between ripening temperature and breakdown has not been demonstrated so clearly in other investigations. These results undoubtedly indicate the chief reason for Bartlett pears failing to ripen satisfactorily in retail stores at eastern markets. In New York it is not uncommon for the average street-level temperature to remain above 80°F. for extended periods. Visits to stores during July, August and September revealed that retailers had trouble ripening the fruit only during periods of such high temperatures. Before recommendations can be made for the commercial application of the ripening results, additional information is needed. If fully ripened by the wholesaler or jobber the fruit would require extremely careful handling during delivery in order to prevent bruising. On the other hand, few retailers have facilities for ripening the fruit at temperatures of 65° to 70°.

SUMMARY

The results obtained in the experimental work should be considered as suggestive rather than conclusive since they are based upon tests made during only one season.

It was found that the Bartlett pears from California were refrigerated adequately in every test shipment and in many instances they were refrigerated more than was actually needed to satisfy the market preference for pears with some yellow-green to yellow color upon arrival. Softening in transit was generally negligible, averaging about one pound difference in pressure test. In a few warm shipments fruit softened 3 to 5 pounds by pressure test but was still firm to hard on arrival. Low transit temperatures had no apparent effect on flavor of the pears, evenness of ripening, the amount of breakdown that developed or the period the fruit was marketable after it was ripened.

Transit temperatures were influenced largely by the precooling the fruit received rather than by the number of icings in transit. Length of precooling was the principal factor in reducing the temperature of the fruit. To precool pears to 45° or 50° required 18 to 24 hours and to precool them to approximately 32° required 61 to 119 hours. In cooling to 45° or 50° the rate averaged 1° to 1½° per hour but in cooling to 32° it averaged only 0.4° to 0.9° per hour.

In evaluating the effectiveness of precooling, emphasis should be placed on the length of the precooling period rather than on taking a few fruit temperatures at the outside of accessible boxes. Ice meltage is also a good indication of the cooling accomplished, about $2\frac{1}{2}^{\circ}$ reduction in temperature being obtained in heavy loads of pears by the meltage of 1,000 pounds of ice. In these tests, the temperature of pears in the center of boxes in the top layer of the doorway stack was close to the average of the load in cars cooled with fans at the top bulkhead opening, but in a car cooled by blowing air into it through the doorway the temperature in the top layer of the bunker stack was closer to the car average.

The temperature at which pears were ripened had a marked effect on flavor and breakdown. When ripened at 65° to 70°, either at Davis, California or New York City, pears developed good flavor with juicy flesh and attractive color. There was some indication that 65° was better than 70°, but temperatures as low as 47° and 57° were not as good as 65°. At temperatures above 80°, which are often encountered on the market in July and August, the fruit ripened imperfectly and had an insipid flavor, remaining hard and woody or becoming dry and mealy. Breakdown occurred in 46 out of 54 lots ripened at 81° to 83° as compared to only 3 of the 54 comparable lots ripened at 66° to 68°. It appears from these results that relatively cool ripening temperatures are needed to prevent the losses that have been reported from breakdown and poor quality and appearance.

ACKNOWLEDGEMENTS

The agencies engaged in this work wish to express their appreciation to the shippers and growers whose wholehearted cooperation made the work possible, also to the committees which were helpful in outlining the problems and suggesting methods of attack, and to the precooling agencies, cold storage firms, refrigerator car companies and railroads which gave their assistance.

TABLE 1. LIST OF TEST SHIPMENTS
1941

TEST NO.	CAR NUMBER	DATE LOADED	DATE UNLOADED	PRECOOLING DATA			REFRIGERATION IN TRANSIT 5/	SHIPPER	SHIPPING POINT
				METHOD	HOURS COOLED	FINAL TEMP. 4/ °F			
	P.F.E.								
1	97564	7-11	7-21	None	None	74	Replenished, reiced Ogden	Lambert Mktg. Co.	Locke
2	96569	do	7-22	Fans,ice1/	18	49	do	do	do
3	52224	7-14	7-25	None	None	--	Standard Refrigeration	Earl Fruit Co.	Yuba City
4	52287	do	7-30	Fans,ice2/	45	35	Replenished, reiced Council Bluffs	do	do
5	30137	do	7-25	Fans,ice2/	15	63	Standard Refrigeration	do	do
6	51204	7-19	7-31	Fans,ice1/	23.5	46	Replenished, reiced N.Platte	American Frt.Grs.	Walnut Gro.
7	50963	do	8-5	Warehouse	119	30	Reice Kansas City and Marion	Calif. Frt. Exch.	Sacramento
8	37109	7-23	8-6	Fans,ice2/	41	39	Replenished, reiced Council Bluffs	Earl Fruit Co.	Yuba City
9	37776	do	8-4	Fans,ice2/	59	31	do	do	do
10	51149	7-25	do	None	None	--	Standard Refrigeration, 3% salt	Stillwater Ochds.	Hood
11	73346	do	8-5	Fans,ice1/	24.5	41	Replenished, reiced, Laramie,Chicago	do	do
12	98320	8-2	8-14	Fans,ice1/	26	40	Standard ref., Eventemp fans	do	do
13	90988	8-4	8-18	Fans,ice2/	61	34	Replenished, reiced Council Bluffs	Earl Fruit Co.	Yuba City
14	70160	do	do	Fans,ice2/	39	38	do	do	do
15	70476	8-7	do	Mech.ref.3/	19.5	47	Replenished, reiced Council Bluffs	Lake Co. Frt.Exch.	Ukiah
16	40262	do	8-21	Warehouse	81	31	Reiced, Council Bluffs	Kelseyville Pkg.Co.	Yuba City
17	40139	8-11	8-22	Fans,ice1/	21.3	49	Standard Refrigeration	Simons & French Co.	Placerville
18	41489	8-11	8-25	Warehouse	92.25	33	No reicings	Calif. Frt. Exch.	do
19	31658	8-27	9-11	Warehouse	96	30	Reiced, Council Bluffs	Kelseyville Pkg.Co.	Yuba City

1/ Phillips portable propeller fans.
2/ Utility portable propeller fans.
3/ General American trackside ammonia coils.
4/ The average of nine fruit temperatures in the center of boxes in bottom, middle, and top layers of the load.
5/ All cars precool.

TABLE 2. APPEARANCE OF PEARS ON ARRIVAL AS INFLUENCED BY THE AMOUNT OF REFRIGERATION THEY RECEIVED IN TRANSIT.1/ - 1941

LOT	DISTRICT	CAR 8 - LOADED JULY 25 AVE. TRANSIT TEMP.--49.8°F	CAR 9 - LOADED JULY 23 AVE. TRANSIT TEMP.--43.4°F
1	Placer Co.	Excellent color for auction display	Too green for best auction display
2	do	do	do
3	Marysville	Good color for auction display	do
4	do	Excellent color for auction display, slightly irregular	do
		CAR 10 - LOADED JULY 25 AVE. TRANSIT TEMP.--52.4°F	**CAR 11 - LOADED JULY 25 AVE. TRANSIT TEMP.--43.1°F**
1	Placer Co.	Good appearance for auction disp.	Too green for best auction display
2	do	Excellent color for auction disp.	Good color for auction display
3	Sacto.Riv.	Good color for auction display	do
4	do	do	Too green for best auction display
		CAR 14 - LOADED AUG. 4 AVE. TRANSIT TEMP.--47.3°F	**CAR 13 - LOADED AUG. 4 AVE. TRANSIT TEMP.--38°F**
1	Marysville	Excellent for auction display	Too green for best auction display
2	do	do	Good color for auction display
3	Placer Co.	Good color for auction display	Fairly good color for auction disp.
4	do	Excellent color for auct.disp.	Excellent color for auction display
		CAR 15 - LOADED AUG. 7 AVE. TRANSIT TEMP.--44.8°F	**CAR 16 - LOADED AUG. 7 AVE. TRANSIT TEMP.--41.0°F**
1	Lake Co.	Slightly green for best auction display	Too green for best auction display
2	do	Color variable but average, excellent for auction display	do
		CAR 17 - LOADED AUG. 11 AVE. TRANSIT TEMP.--43.9°F	**CAR 18 - LOADED AUG. 11 AVE. TRANSIT TEMP.--40.9°F**
1	Placerville	Too green for best auction display	Slightly green for best auction display
2	do	Slightly green for best auction display	do
3	do	Excellent for auction display	Good for auction display

1/ Test fruit from cars 1-7 inclusive, all too green on arrival for best auction display.

TABLE 3. SOFTENING OF PEARS IN TRANSIT AS INFLUENCED BY METHOD OF REFRIGERATION
1941

Car No.	Date Loaded	Days Until Unloaded	Lot	Pressure Test When Packed	Pressure Test On Arrival	Amount Softened	Average Temperature 2/	Refrigeration
				Pounds	Pounds	Pounds	°F	
					Top Layer, Doorway			
1	July 11	10	1	20.5	16.4	4.1	57.2	Nonprecooled, 1 reicing
			2	19.6	18.0	1.6	do	do
2	do	11	1	20.5	18.0	2.5	46.6	Precooled to 49°, 1 reicing
			2	19.6	18.5	1.1	do	do
3	July 14	11	1	22.0	20.9	1.1	55.5	Nonprecooled, std. ref.
			2	18.1	19.2	1/1.1	do	do
4	do	16	1	22.0	21.4	0.6	42.8	Precooled to 35°, 1 reicing
			2	18.1	18.5	1/0.4	do	do
5	do	11	1	22.0	20.7	1.3	55.5	Precooled to 65°, std. ref.
6	July 19	12	1	16.7	16.5	0.2	45.8	Precooled to 46°, 1 reicing
			2	17.6	17.7	1/0.1	do	do
7	do	17	1	16.7	17.7	1/1.0	41.6	Precooled to 30°, 2 reicings
			2	17.6	18.6	1/1.0	do	do
8	July 23	14	1	20.6	17.8	1/2.8	49.8	Precooled to 39°, 1 reicing
			2	20.7	17.3	3.4	do	do
			3	21.4	17.7	3.7	do	do
			4	19.7	14.7	5.0	do	do
9	do	12	1	20.6	21.2	1/0.6	43.4	Precooled to 31°, 1 reicing
			2	20.7	18.9	1.8	do	do
			3	21.4	20.0	1.4	do	do
			4	19.7	18.6	1.1	do	do
10	July 25	10	1	21.3	20.3	1.0	52.4	Nonprecooled, std.ref.3% salt
			2	19.9	19.3	0.6	do	do
			3	19.4	18.2	1.2	do	do
			4	18.1	16.6	1.5	do	do
11	do	11	1	21.3	21.2	0.1	43.1	Precooled to 41°, 2 reicings
			2	19.9	19.6	0.3	do	do
			3	19.4	19.2	0.2	do	do
			4	18.1	18.2	1/0.1	do	do
12	Aug. 2	12	1	16.3	15.3	1.0	44.2	Precooled to 40°, std. ref., Eventemp fans
13	Aug. 4	14	1	18.3	17.9	0.4	38.0	Precooled to 34°, 1 reicing
			2	16.6	17.5	1/0.9	do	do
			3	20.1	19.6	0.5	do	do
			4	17.7	17.7	0.0	do	do
14	do	11	1	18.3	18.6	1/0.3	47.3	Precooled to 38°, 1 reicing
			2	16.6	17.5	1/0.9	do	do
			3	20.1	20.4	1/0.3	do	do
			4	17.7	18.3	1/0.6	do	do

(Cont'd)

TABLE 3. (Cont'd)

Car No.	Date Loaded	Days Until Unloaded	Lot	Pressure Test When Packed	Pressure Test On Arrival	Amount Softened	Average Temperature 2/	Refrigeration
				Pounds	Pounds	Pounds	°F	
				Top Layer, Doorway (cont'd)				
15	Aug. 7	11	1	21.0	20.9	0.1	44.8	Precooled to 47°, 1 reicing
			2	19.7	20.0	1/0.3	do	do
16	do	14	1	21.0	20.6	0.4	41.0	Precoolod to 71°, 1 reicing
			2	19.7	18.8	0.9	do	do
17	Aug. 11	11	1	21.0	17.7	3.3	46.9	Precooled to 49°, std.ref.
			2	20.3	18.1	2.2	do	do
			3	21.0	17.9	3.1	do	do
18	do	14	1	21.0	17.6	3.4	40.9	Precooled to 33°, initial ice only
			2	20.3	18.6	1.7	do	do
			3	21.0	18.1	2.9	do	do
19	Aug. 27	15	1	17.1	16.6	0.5	41.1	Precooled to 30°, 1 reicing
				Bottom Layer, Bunker				
2	July 14	11	1	22.0	21.7	0.3	42.7	Nonprecooled std. ref.
			2	18.1	18.5	1/0.4	do	do
10	July 25	10	1	21.3			41.7	Nonprecooled, std.ref.3% salt
			2	19.9			do	do
			3	19.4	18.8	0.6	do	do
			4	18.1			do	do
1	July 11	10	1	20.5	19.4	1.1	----	Nonprecooled, 1 reicing
			2	19.6	18.2	1.4	----	do

1/ Gain in firmness.

2/ Average temporature of fruit during precooling and in transit

TABLE 4. RELATION OF TRANSIT TEMPERATURE TO BREAKDOWN OF PEARS, AFTER RIPENING AT HIGH TEMPERATURES FAVORABLE TO ITS DEVELOPMENT

1941

Lot and Car Number	Transit Temperatures Compared		Breakdown in lots shipped at	
	Higher Temp.	Lower Temp.	Higher temp.	Lower Temp.
	°F.	°F.	Pct.	Pct.
Lot 1 Cars 1 and 2	57	47	6	0
Lot 2 do	do	do	5	2
Lot 1 Cars 3 and 4	56	43	3	25 1/
Lot 2 do	do	do	17	56 1/
Lot 1 Cars 6 and 7	46	42	13	45 2/
Lot 2 do	do	do	25	38 2/
Lot 1 Cars 8 and 9	50	43	6	1
Lot 2 do	do	do	4	1
Lot 3 do	do	do	22	3
Lot 4 do	do	do	26	25
Lot 1 Cars 10 and 11	52	43	20	4
Lot 2 do	do	do	19	3
Lot 3 do	do	do	22	7
Lot 4 do	do	do	19	42
Lot 1 Cars 13 and 14	47	38	0	0
Lot 2 do	do	do	25	19
Lot 3 do	do	do	0	0
Lot 4 do	do	do	0	0
Lot 1 Cars 17 and 18	47	41	0	6 1/
Lot 2 do	do	do	9	4 1/
Lot 3 do	do	do	12	12 1/
Lot 1 Top & Bottom layer	56	43	3	16
Lot 2 of Car 3	do	do	17	14
		Average	11.9	14.0

1/ Required 4 to 5 days longer to ripen than lot shipped in warmer car.
2/ Seven days longer ripening period required than for lot from warmer car.

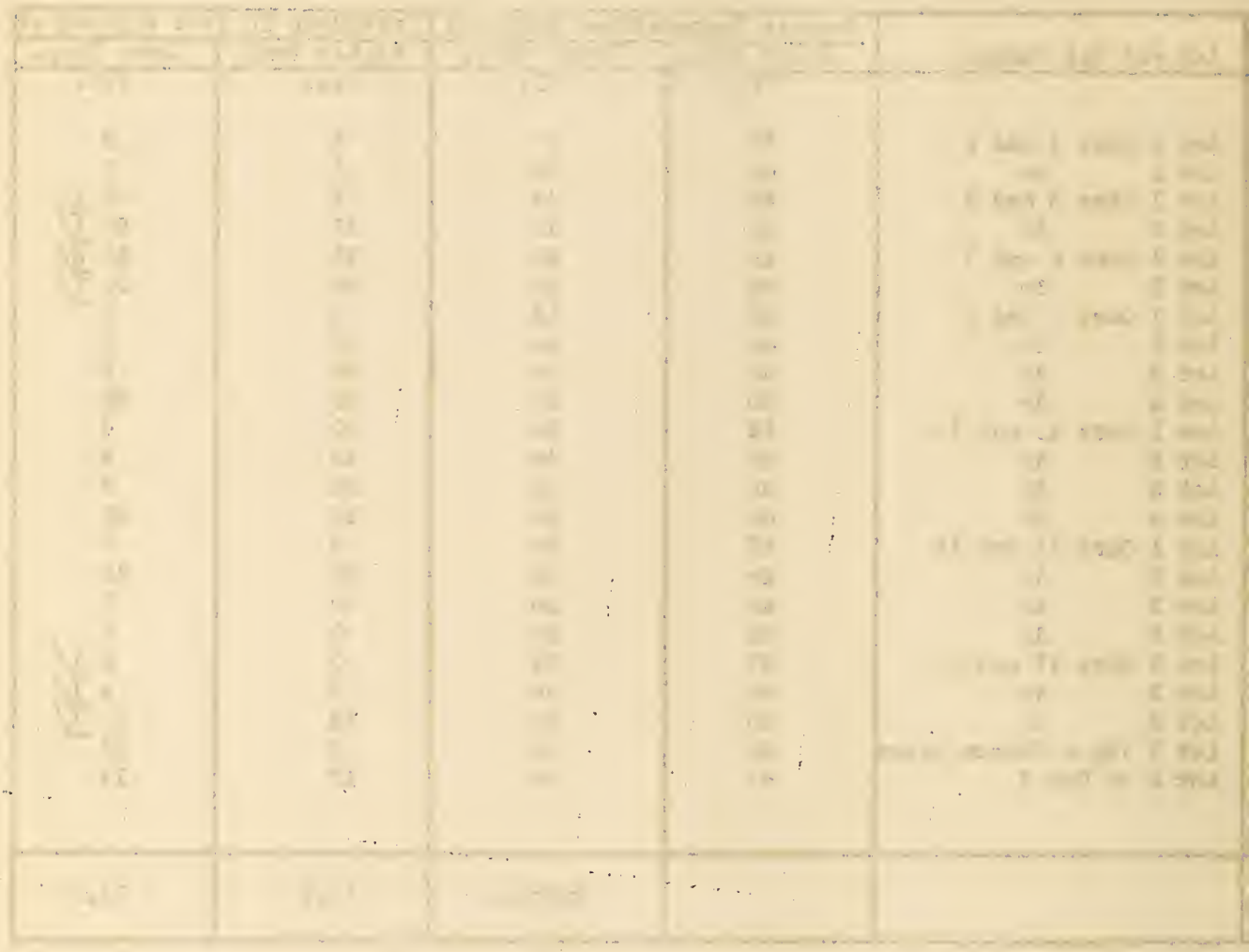


TABLE 5. SUMMARY OF PRECOOLING TESTS WITH BARTLETT PEARS, 1941 SEASON

Test	Car No.	Fruit temperatures average of 9 positions		Temperature drop		Cooling period		Salt used and ice melted during cooling		Temperature drop per 1000 lbs. ice melted.	Average air blast temp.	Precooling equipment
	PFE	Start	Finish	Total	Per Hour	Hr.	Min	Salt	Ice			
		°F	°F	°F	°F			lb.	lb.	°F	°F	
1	97564	74.5	73.9	0.6	0.13	4	30	none	4,614	0.13	69.8	None
2	96569	72.7	48.9	23.8	1.36	17	30	750	8,693	2.74	32.9	2 Phillips ½h.p. fans
4	52287	70.6	34.6	36.0	0.90	39	45	1000	13,600	2.65	32.6	2 Utility ½h.p. fans
5	51204	68.0	62.9	5.2	0.37	14	10	none	----	----	62.2	2 Utility ½h.p. fans
6	50963	78.7	46.2	32.5	1.38	23	25	956	9,903	3.28	33.7	4 Phillips ¼h.p. fans
7	37109	71.4	29.7	41.7	.35	118	45	none	none	----	30.6	Warehouse
8	37776	82.7	39.4	43.3	1.04	41	35	750	11,650	3.73	33.8	2 Utility ½h.p. fans
9	51149	75.9	30.9	45.0	0.74	60	55	875	12,150	3.70	31.3	2 Utility ½h.p. fans
11	73346	69.6	41.2	28.4	1.14	25	00	954	11,105	2.56	31.2	2 Phillips ½h.p. fans
13	90988	71.0	33.9	37.1	0.61	60	40	1000	15,000	2.47	32.5	2 Utility ½h.p. fans
14	70160	69.9	37.8	32.1	0.85	37	50	1000	12,500	2.57	31.2	2 Utility ½h.p. fans
15	70476	75.9	46.8	29.1	1.49	19	30	none	none	----	36.8	Trackside coils and fans
16	40262	74.2	31.0	43.2	0.53	80	15	none	none	----	28.2	Warehouse
17	40139	70.2	48.9	21.3	1.00	21	20	625	8,326	2.56	38.1	2 Phillips ½h.p. fans
18	41489	69.2	32.7	36.5	0.39	92	15	none	none	----	30.0	Warehouse-precooled

TABLE 6. TEMPERATURE OF PEARS IN THE TOP LAYER, DOORWAY STACK IN COMPARISON WITH AVERAGE TEMPERATURE OF THE LOAD AFTER PRECOOLING.

1941

TEST	PRECOOLING METHOD	COOLING PERIOD		AVERAGE 1/ TEMPERATURE	TOP DOORWAY TEMPERATURE	TOP DOORWAY COMPARED TO AVERAGE TEMP.
		Hrs.	Min.	°F	°F	°F
2	Fans and ice	17	30	49	47	-2
4	do	39	45	35	38	+3
6	do	23	25	46	43	-3
7	Warehouse	118	45	30	30	0
8	Fans and ice	41	35	39	44	+5
9	do	60	55	31	32	+1
11	do	25	00	41	39	-2
13	do	60	40	34	35	+1
14	do	37	50	38	40	+2
15	Trackside coils	19	30	47	34	-13
16	Warehouse	80	15	31	33	+2
17	Fans and ice	21	20	49	53	+4
18	Warehouse	92	15	33	32	-1

1/ All temperatures taken in the center of the box with resistance thermometers. Positions averaged were top, middle, and bottom layers, bunker, quarter length, and doorway stacks along center line of car.

TABLE 7. COMPARISON OF THE FLAVOR OF BARTLETT PEARS GROWN IN DIFFERENT DISTRICTS. 1/
1941

DISTRICT	Average Flavor Score Of Test Lots When Ripened At Temp. 81°-83°F.					
	Early		Midseason		Late	
	Harvest Date	Score	Harvest Date	Score	Harvest Date	Score
Sacramento Valley	July 11-14	50	July 20-26	55	Aug. 2-14	70
Placer County	July 25-26	60	Aug. 2-7	63		
Lake County	Aug. 9	54				
Placerville	Aug. 12-15	58				

DISTRICT	Average Flavor Score of Test Lots When Ripened At Temp. 66°-68°F.					
	Early		Midseason		Late	
	Harvest Date	Score	Harvest Date	Score	Harvest Date	Score
Sacramento Valley	July 11-14	69	July 20-26	76	Aug. 2-14	78
Placer County	July 25-26	77	Aug. 2-7	73		
Lake County	Aug. 9	79				
Placerville	Aug. 12-15	78				

1/ Flavor Score: Poor 0-24; Fair 25-49; Cood 50-74; Excellent 75-100.

TABLE 8. COMPARISON OF THE FLAVOR OF BARTLETT PEARS AS AFFECTED BY RIPENING TEMPERATURE.

1941

CAR	LOT	RIPENING TEMPERATURE High 81°-83° Flavor score 1/	RIPENING TEMPERATURE Low 66°-68° Flavor score 1/	SUPERIORITY OF LOW TEMP. RIPENING Points in Flavor score 1/
1	1	45	62	17
	2	50	70	20
2	1	63	63	0
	2	52	73	21
3	1	50	82	32
	2	53	77	24
4	1	43	63	20
	2	42	73	31
5	1	48	68	20
6	1	55	77	22
	2	52	73	21
7	1	48	73	25
	2	40	68	28
8	1	60	71	11
	2	63	75	12
	3	57	67	10
	4	55	79	24
9	1	60	77	17
	2	48	80	32
	3	55	72	17
	4	52	75	23
10	1	59	75	16
	2	70	81	11
	3	57	84	27
	4	57	85	28
11	1	57	82	25
	2	59	82	23
	3	60	80	20
	4	58	78	20
13	1	70	70	0
	2	62	77	15
	3	62	75	13
	4	62	76	14
14	1	75	79	4
	2	67	75	8
	3	60	68	8
	4	70	77	7
15	1	55	75	20
	2	60	77	17
16	1	75	79	4
	2	68	75	7
	3	60	68	8
	4	70	78	8
17	1	52	82	30
	2	62	87	25
	3	62	85	23
18	1	58	68	10
	2	60	78	18
	3	63	70	7
19	1	73	83	10
3 2/	1	58	75	17
10 2/	2	58	77	19
10 2/	3	63	80	17
Average of 53 lots-		58.4	75.6	17.0

1/ Flavor ratings were: 0-24 poor, 25-49 fair, 50-74 good, 75-100 excellent.

2/ Fruit shipped in bottom layer of bunker stack, all other lots shipped in the top layer of the doorway stack.

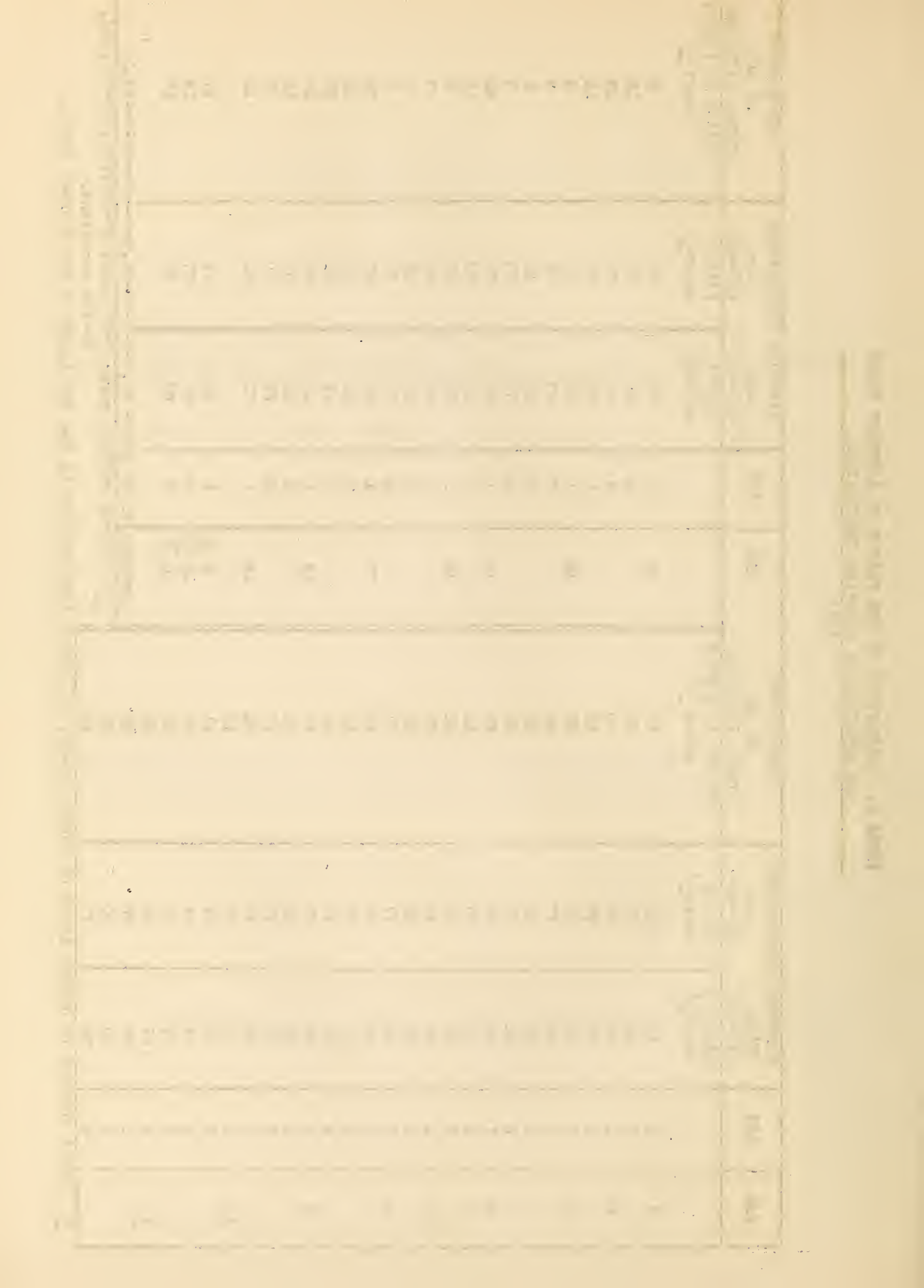


TABLE 9. INFLUENCE OF TEMPERATURE UPON THE RIPENING OF BARTLETT PEARS
UNIVERSITY FARM, DAVIS, CALIFORNIA - 1941
(All samples held for 10 days at 42°F. before ripening)

TEST	LOT	DATE HARVESTED	RIPENING RECORD		WHEN RIPE		QUALITY
			TEMP. °F.	DAYS	APPEARANCE	COLOR	
8-9	1	7/22	65°	6	Good	Yellow	Good
			70°	6	"	"	"
			90°	18	Poor	Scald and decay preceded development of yellow color	Poor; insipid
	2	7/22	65°	6	Good	Yellow	Good
			70°	6	"	"	"
			90°	18	Poor	Slight scald and decay preceded yellow color	Poor; insipid
	3	7/23	65°	6	Good	Yellow	Fair
			70°	6	"	"	"
			85-90°	17	Poor	Yellow preceded by severe decay; slight scald and breakdown	Poor
10-11	2	7/25	65°	5	Good	Yellow	Good
			70-75°	5	"	"	"
			85-90°	12	Fair	Light yellow to yellow; flesh hard and woody; ripening very imperfect.	Poor; insipid
	4	7/25	65°	5	Good	Yellow	Fair-good
			70-75°	4	Mostly good	Yellow; slight breakdown	" "
			85-90°	12	Poor	Greenish yellow; flesh hard; severe decay and breakdown	Poor, insipid
13-14	1	8/4	65°	4	Excellent	Full yellow	Mostly good
			70°	4	"	" "	Fair
			85-90°	11	Poor	Pale dull yellow; 50% scald when ripe	Very poor; insipid to slight acid
	2	8/4	65°	4	Excellent	Full yellow	Fair-good
			70°	4	"	" "	Fair
			85°	7	Fair	Greenish yellow to light yellow; 60% breakdown when ripe	Poor

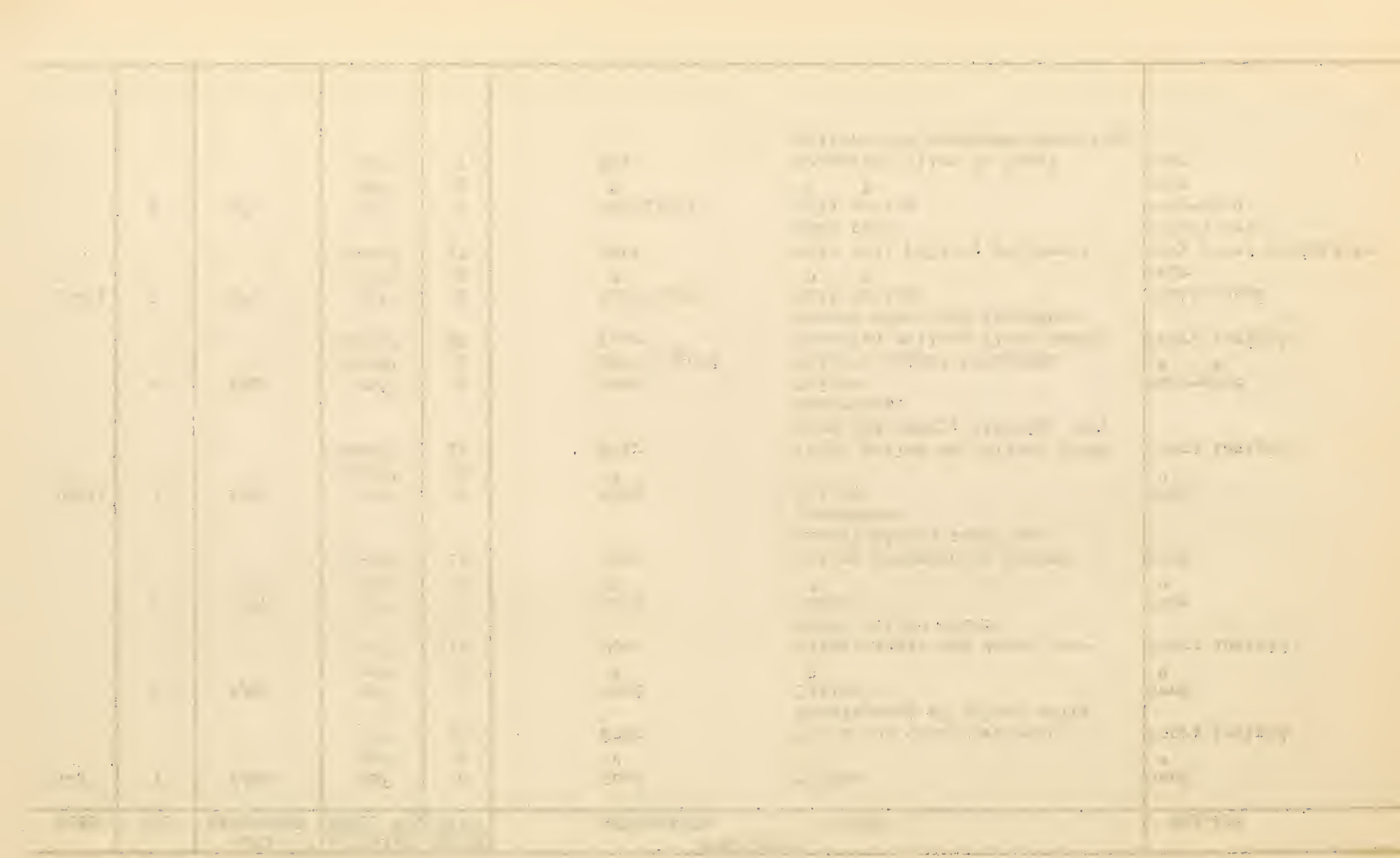


TABLE 9. (Cont'd)

TEST	LOT	DATE HARVESTED	RIPENING RECORD TEMP. °F.	DAYS	WHEN RIPE APPEARANCE	COLOR	QUALITY
17-18	2	8/11	65°	4-5	Good	Full yellow	Fair-good
			70°	4	"	" "	Fair
			85°	6	Rather poor	Dull yellow; failed to ripen properly	Poor; insipid
	3	8/11	65°	5	Good	Full yellow	Fair
			70°	4	"	" "	"
			85°	6-7	Poor	Greenish yellow to light yellow; failed to ripen properly	Poor; insipid
19	1	8/27	57°	9	Good	Full yellow	Fair
			65°	4	Excellent	" "	Excellent
			70°	4	"	" "	Good
			85°	9	Poor	Greenish yellow to pale yellow; mostly failed to ripen	Very poor; acid, insipid
	2	8/28	47°	12	Good	Full yellow	Good
			57°	10	"	" "	"
			65°	5	"	" "	"
			70°	5	"	" "	"
			85°	9	Poor	Greenish yellow; black end, decay and scald preceded ripening	Very poor; acid; insipid
	3	8/28	57°	9	Good	Yellow	Fair
			65°	5	"	Full yellow	Fair-good
			75°	4-5	"	" "	" "
			85°	9	Rather poor	Dull yellow; slight scald preceded imperfect ripening	Poor; acid; insipid

TABLE 10. THE EFFECT OF RIPENING TEMPERATURE ON COLOR, BREAKDOWN, AND TIME REQUIRED TO RIPEN

1941

LOT	DATE PACKED	COLOR 1/		BREAKDOWN 3/		RIPENING PERIOD	
		HIGH TEMP.	LOW TEMP.2/	HIGH TEMP.	LOW TEMP.	HIGH TEMP.	LOW TEMP.
		81°-83°	66°-68°	81°-83°	66°-68°	81°-83°	66°-68°
				Pct.	Pct.	Days	Days
1-D-1	7/11	3½-4½	4½	6	2	3	3
1-D-2	do	3½	4	5	0	3	4
1-B-1	do	3½	4+	3	0	8	6
1-B-2	do	3¼	4+	4	0	8	6
2-D-1	do	3	3-3/4	0	0	3	3
2-D-2	do	3½	4	2	0	4	4
3-B-1	7/14	4¼	4½	16	0	9	6
3-B-2	do	4¼	4½	14	0	8	5
3-D-1	do	4	4+	3	0	6	5
3-D-2	do	4¼	4+	17	0	5	4
4-D-1	do	3-3/4	4½	25	0	5	4
4-D-2	do	4¼	4+	56	0	5	4
5-D-1	do	4	4+	8	0	5	4
6-D-1	7/19	4	4+	13	0	4	4
6-D-2	do	3-3/4	4½	25	0	4	4
7-D-1	do	4	4½	45	0	6	4
7-D-2	do	4½	4½	38	4	6	4
8-D-1	7/23	4¼	4½	6	0	3	3
8-D-2	do	4	4+	4	0	3	3
8-D-3	do	3-3/4	4+	22	0	3	3
8-D-4	do	4	4+	26	0	3	3
9-D-1	do	4	4½	1	0	8	5
9-D-2	do	4½	4+	1	0	7	5
9-D-3	do	3-3/4	4+	3	0	7	5
9-D-4	do	4¼	4+	25	0	7	5
10-D-1	7/25	3-3/4	4+	20	0	6	5
10-D-2	do	4	4+	19	0	5	5
10-D-3	do	4	4+	22	0	6	5
10-D-4	do	3-3/4	4+	19	0	4	4
10-B-3	do	4	4+	5	0	7	7
11-D-1	do	3½	4+	4	0	7	5
11-D-2	do	4	4+	3	0	6	5
11-D-3	do	3-3/4	4+	7	1½	7	5
11-D-4	do	4	4+	42	2	6	5
12-D-1	8/2	4+	4+	0	0	4	3
13-D-1	8/4	4¼	4+	0	0	4	4
13-D-2	do	--	--	25	0	4	4
13-D-3	do	--	--	0	0	4	4
13-D-4	do	4¼	4+	0	0	4	4
14-D-1	do	4¼	4+	0	0	4	4
14-D-2	do	4¼	4+	19	0	4	4
14-D-3	do	4¼	4+	0	0	4	4
14-D-4	do	4½	4+	0	0	4	4

TABLE 10. (Cont'd)

LOT	DATE PACKED	COLOR 1/ HIGH TEMP. 81°-83°	COLOR 1/ LOW TEMP. 2/ 66°-68°	BREAKDOWN 3/ HIGH TEMP. 81°-83°	BREAKDOWN 3/ LOW TEMP. 66°-68°	RIPENING PERIOD HIGH TEMP. 81°-83°	RIPENING PERIOD LOW TEMP. 66°-68°
				Pct.	Pct.	Days	Days
15-D-1	8/7	3½	4½	4	0	5	5
15-D-2	do	4	4/	2	0	5	4
16-D-1	do	4-	4/	8	0	5	6
16-D-2	do	4-	4/	10	0	5	6
17-D-1	8/11	4½	4/	0	0	4	5
17-D-2	do	4½	4/	9	0	4	5
17-D-3	do	4/	4/	12	0	4	5
18-D-1	do	3-3/4	4/	6	0	7	5
18-D-2	do	4½	4/	4	0	7	5
18-D-3	do	4-	4/	12	0	7	5
19-D-1	8/27	3½	4/	8	0	5	5

1/ Color terms correspond to California State standards. 1-green, 2-light green, 3-greenish yellow, 4-yellow. Full yellow color for Bartlett pears-4/.

2/ The color of the pears ripened at low temperatures was usually more uniform with fewer greenish blotches showing around the lenticels than was the case in the fruit ripened at higher temperatures.

3/ Breakdown of the flesh was usually of the surface type in contrast to the commonly found type that affects the tissue in the core or vascular area.

FIGURE 1 - TEMPERATURES OF PEARS DURING PRECOOLING AND IN TRANSIT
TOP LAYER, DOORWAY STACK

CAR 1 NON-PRECOOLED, SHIPPED RULE 254, REPLENISHED,
REICED ONCE IN TRANSIT, OGDEN, UTAH.
CAR 2 PRECOOLED TO 49°, SHIPPED RULE 254, REPLENISHED,
REICED ONCE IN TRANSIT, OGDEN, UTAH.

PRECOOLING PERIOD ..... TRANSIT PERIOD ———

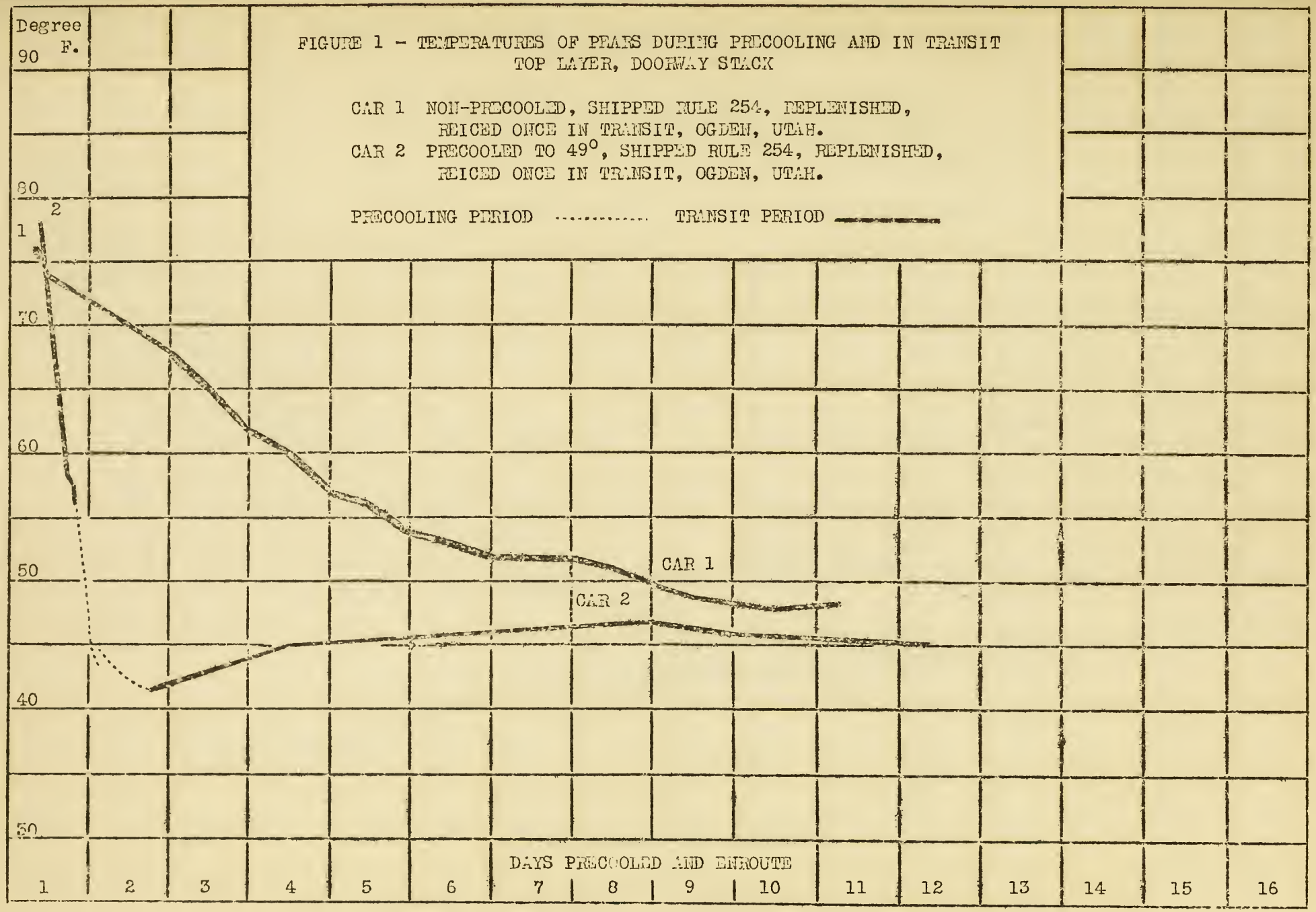
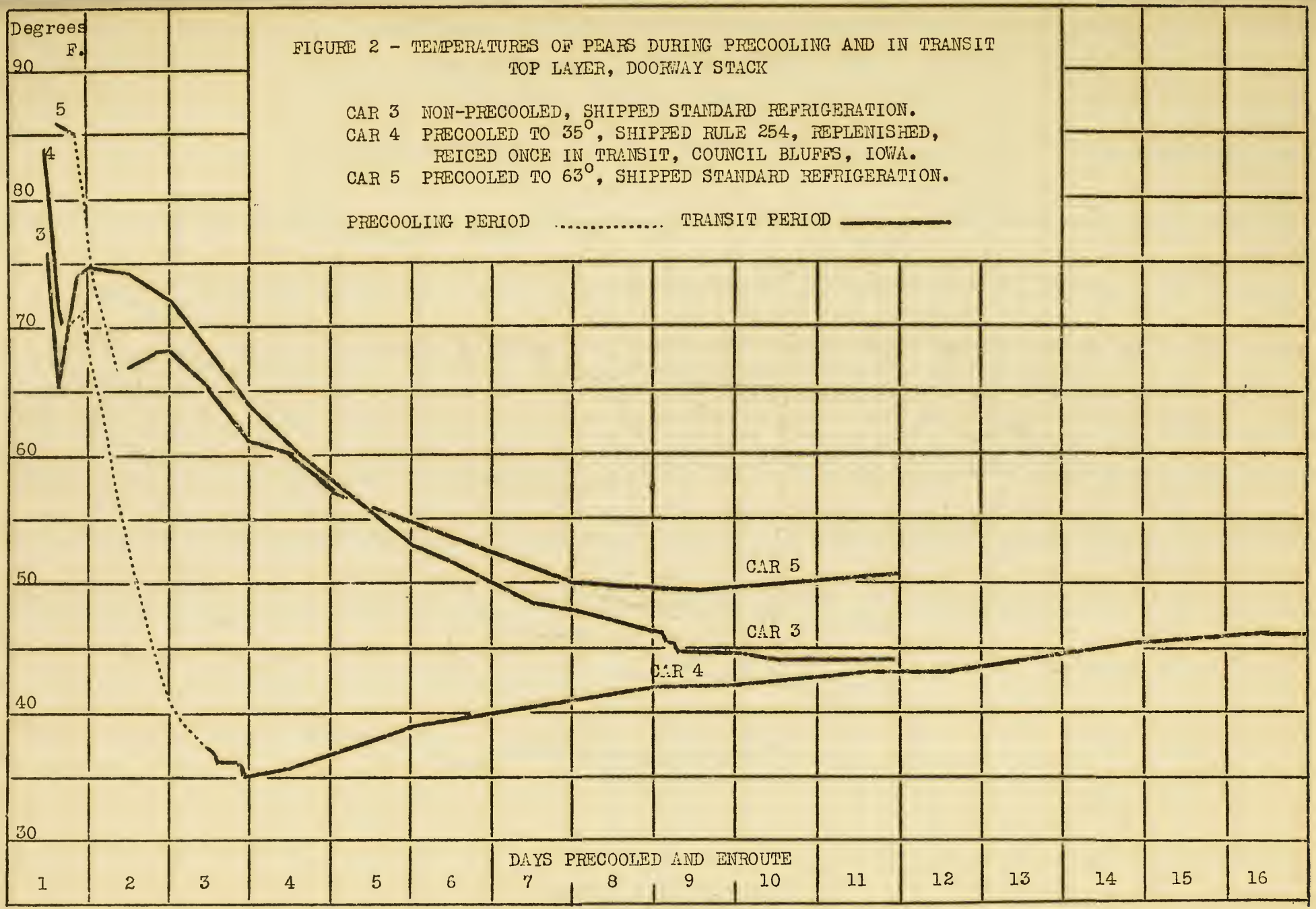


FIGURE 2 - TEMPERATURES OF PEARS DURING PRECOOLING AND IN TRANSIT
TOP LAYER, DOORWAY STACK

CAR 3 NON-PRECOOLED, SHIPPED STANDARD REFRIGERATION.
CAR 4 PRECOOLED TO 35°, SHIPPED RULE 254, REPLENISHED, REICED ONCE IN TRANSIT, COUNCIL BLUFFS, IOWA.
CAR 5 PRECOOLED TO 63°, SHIPPED STANDARD REFRIGERATION.

PRECOOLING PERIOD ..... TRANSIT PERIOD ———



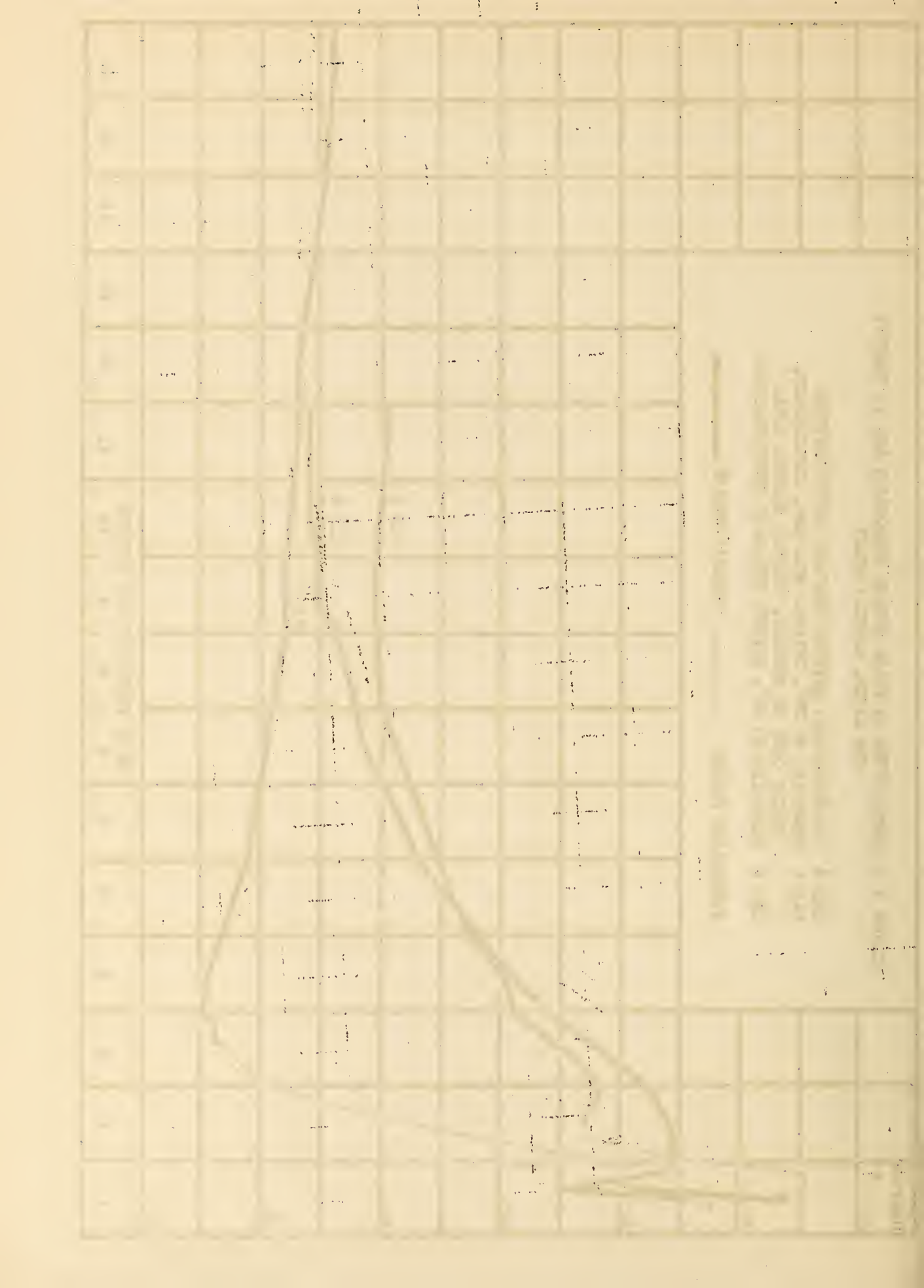
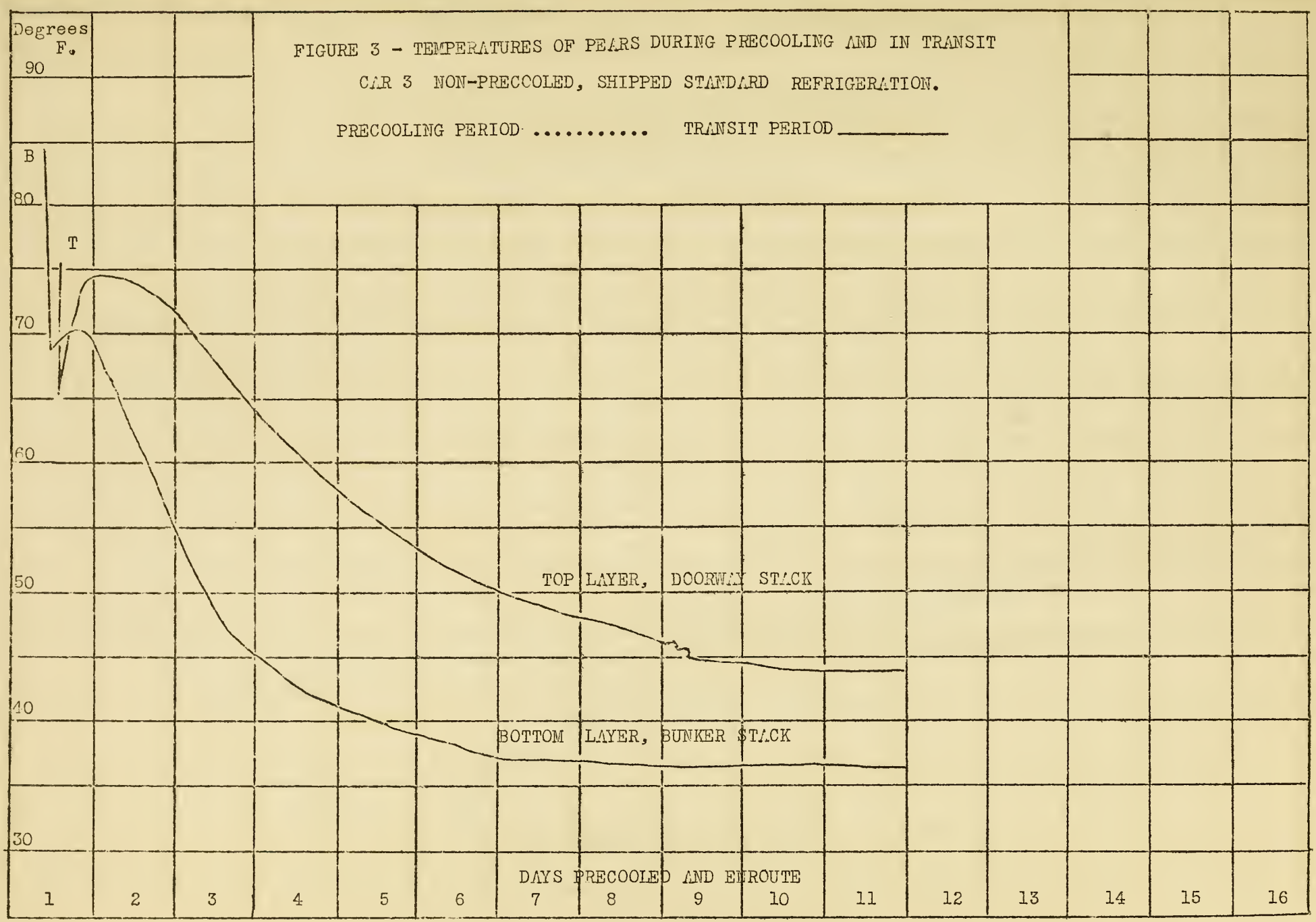


FIGURE 3 - TEMPERATURES OF PEARS DURING PRECOOLING AND IN TRANSIT

CAR 3 NON-PRECOOLED, SHIPPED STANDARD REFRIGERATION.

PRECOOLING PERIOD ..... TRANSIT PERIOD _____



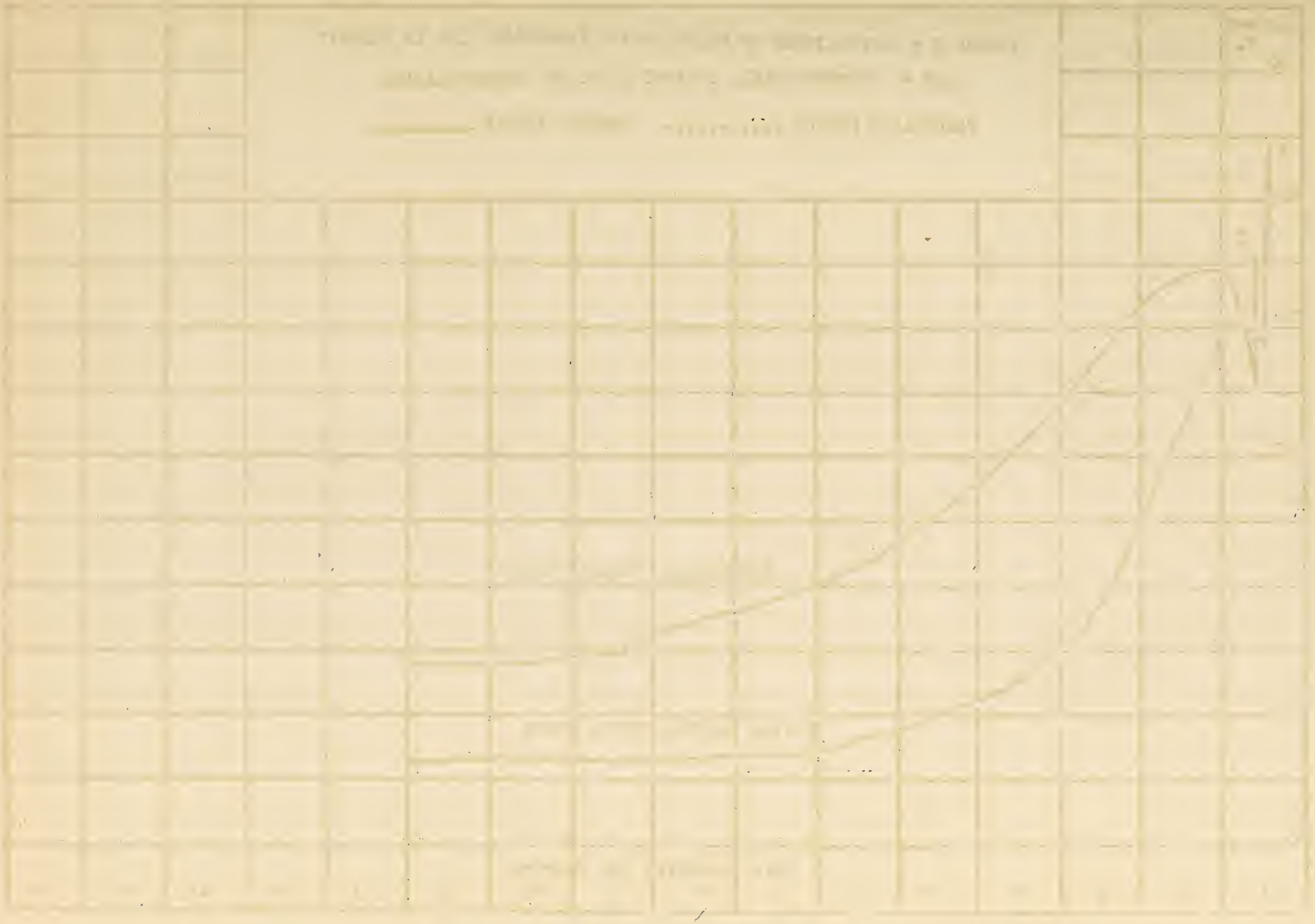
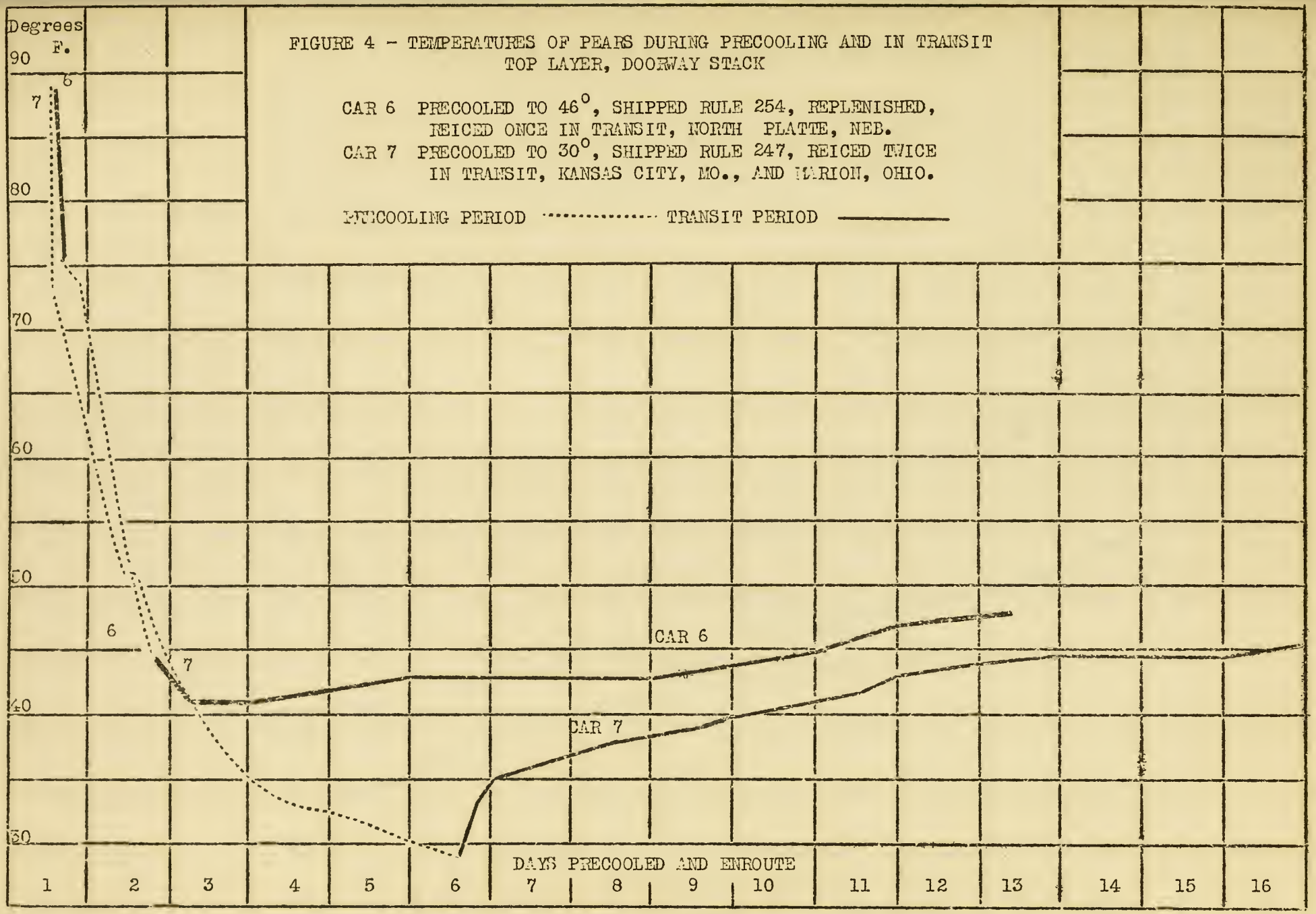


FIGURE 4 - TEMPERATURES OF PEARS DURING PRECOOLING AND IN TRANSIT
TOP LAYER, DOORWAY STACK

CAR 6 PRECOOLED TO 46°, SHIPPED RULE 254, REPLENISHED, REICED ONCE IN TRANSIT, NORTH PLATTE, NEB.
CAR 7 PRECOOLED TO 30°, SHIPPED RULE 247, REICED TWICE IN TRANSIT, KANSAS CITY, MO., AND MARION, OHIO.

PRECOOLING PERIOD ····· TRANSIT PERIOD ——



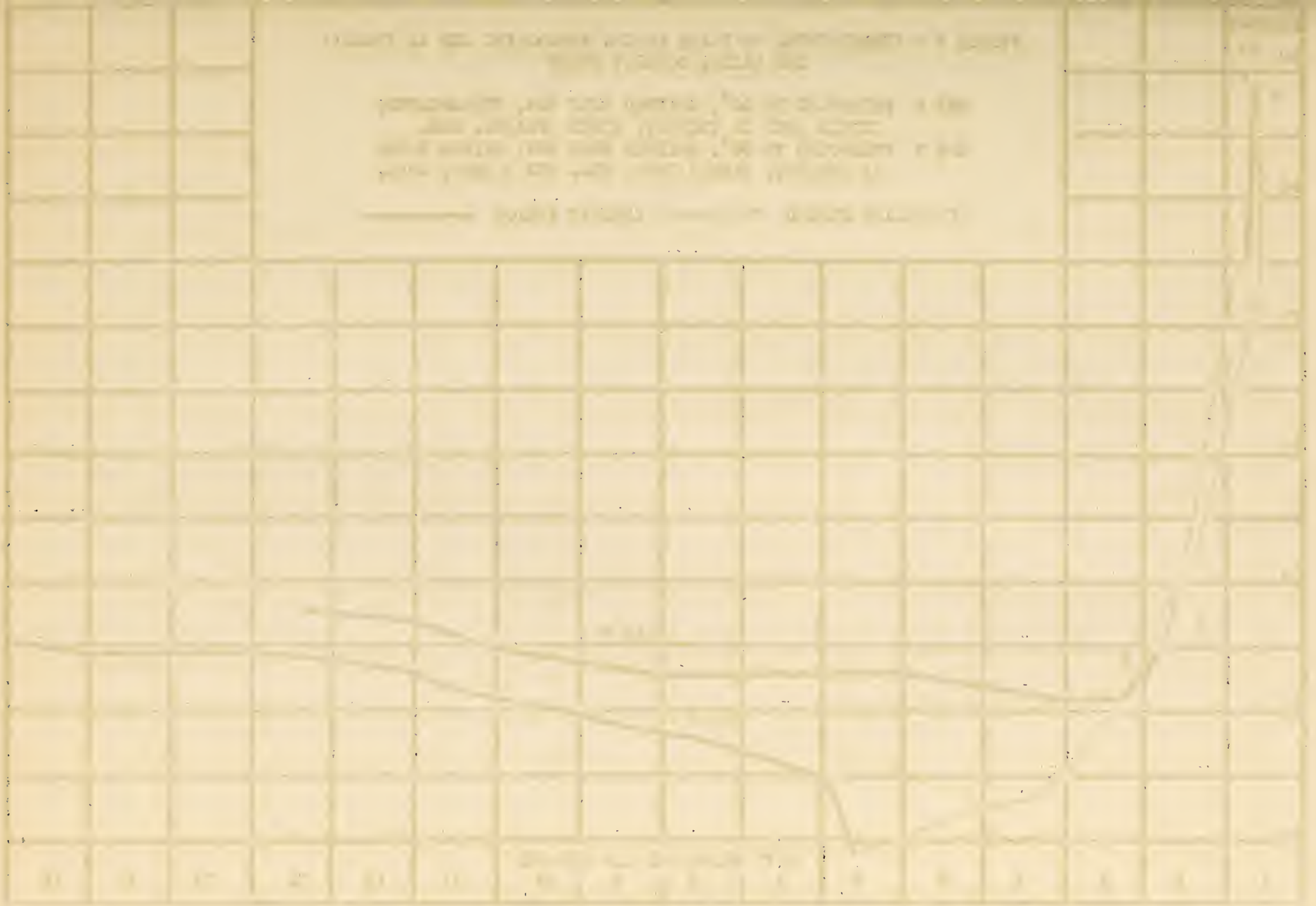
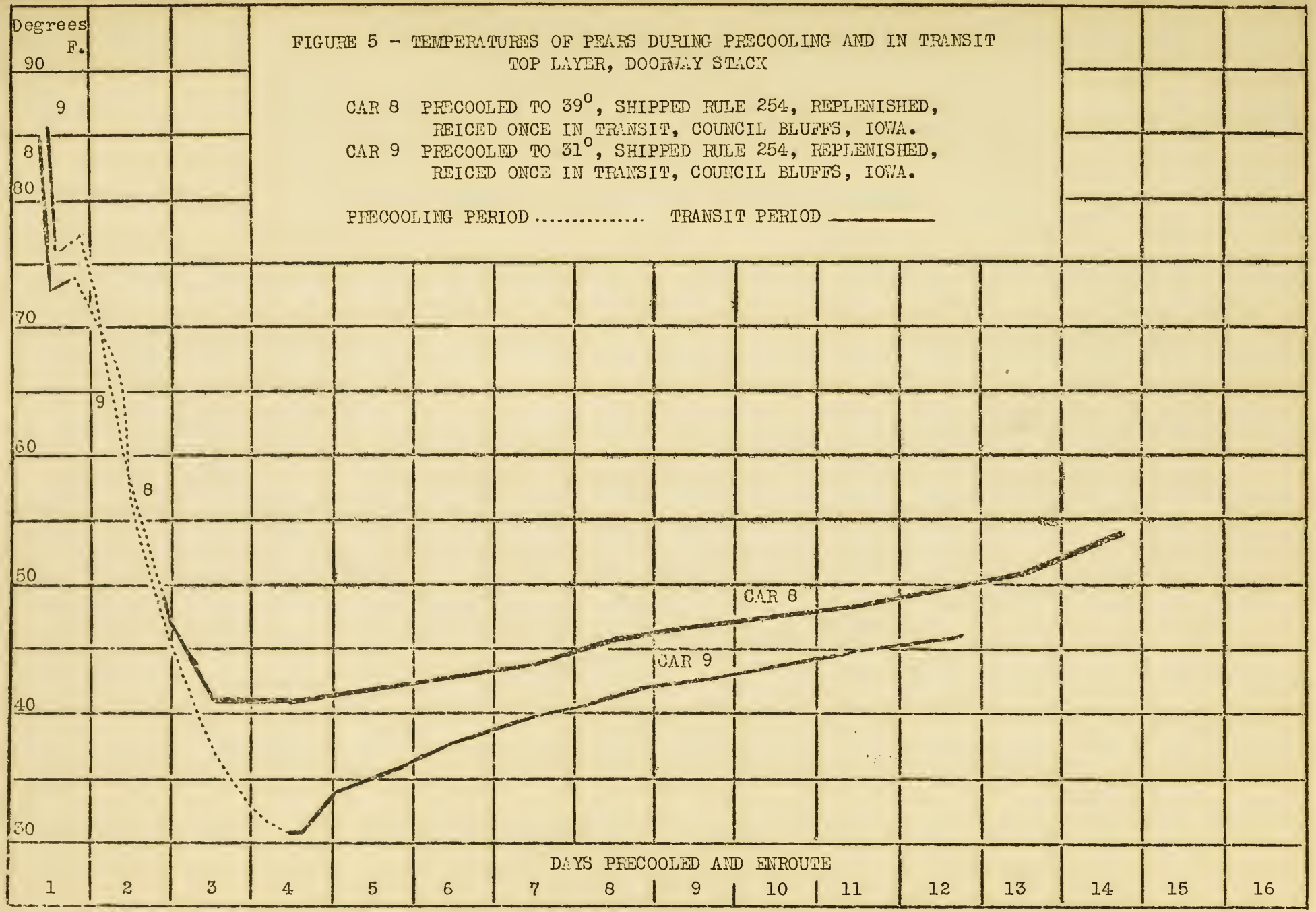


FIGURE 5 - TEMPERATURES OF PEARS DURING PRECOOLING AND IN TRANSIT
TOP LAYER, DOORWAY STACK

CAR 8 PRECOOLED TO 39°, SHIPPED RULE 254, REPLENISHED, REICED ONCE IN TRANSIT, COUNCIL BLUFFS, IOWA.
CAR 9 PRECOOLED TO 31°, SHIPPED RULE 254, REPLENISHED, REICED ONCE IN TRANSIT, COUNCIL BLUFFS, IOWA.

PRECOOLING PERIOD ..... TRANSIT PERIOD ———



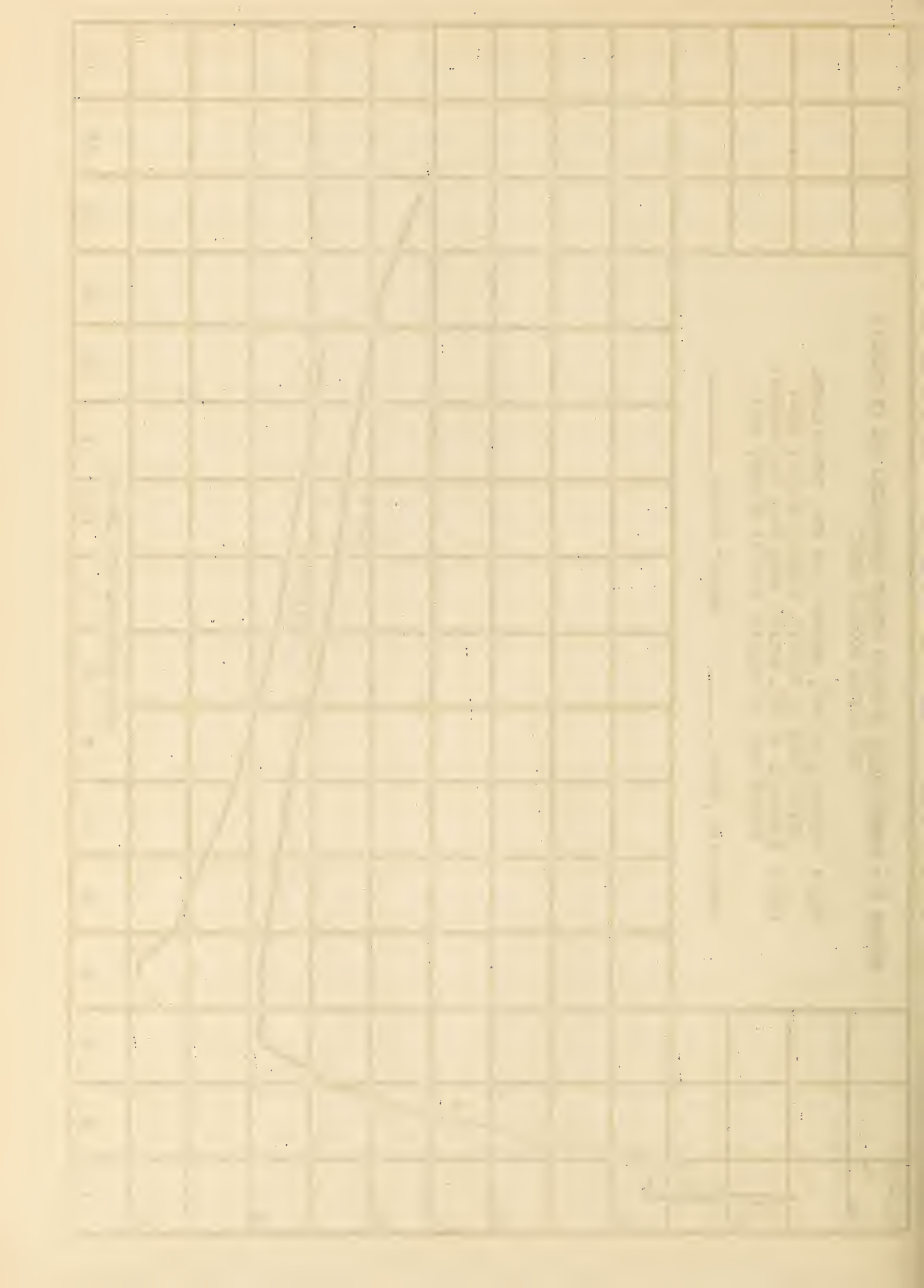


FIGURE 6 - TEMPERATURES OF PEARS DURING PRECOOLING AND IN TRANSIT
TOP LAYER, DOORWAY STACK

CAR 10 NON-PRECOOLED, 550 LOAD, SHIPPED STANDARD REFRIGERATION.
CAR 11 PRECOOLED TO 41°, 720 LOAD, SHIPPED RULE 254, REPLENISHED, REICED TWICE IN TRANSIT, LARAMI, WYO., AND CHICAGO, ILL.

PRECOOLING PERIOD ..... TRANSIT PERIOD ———

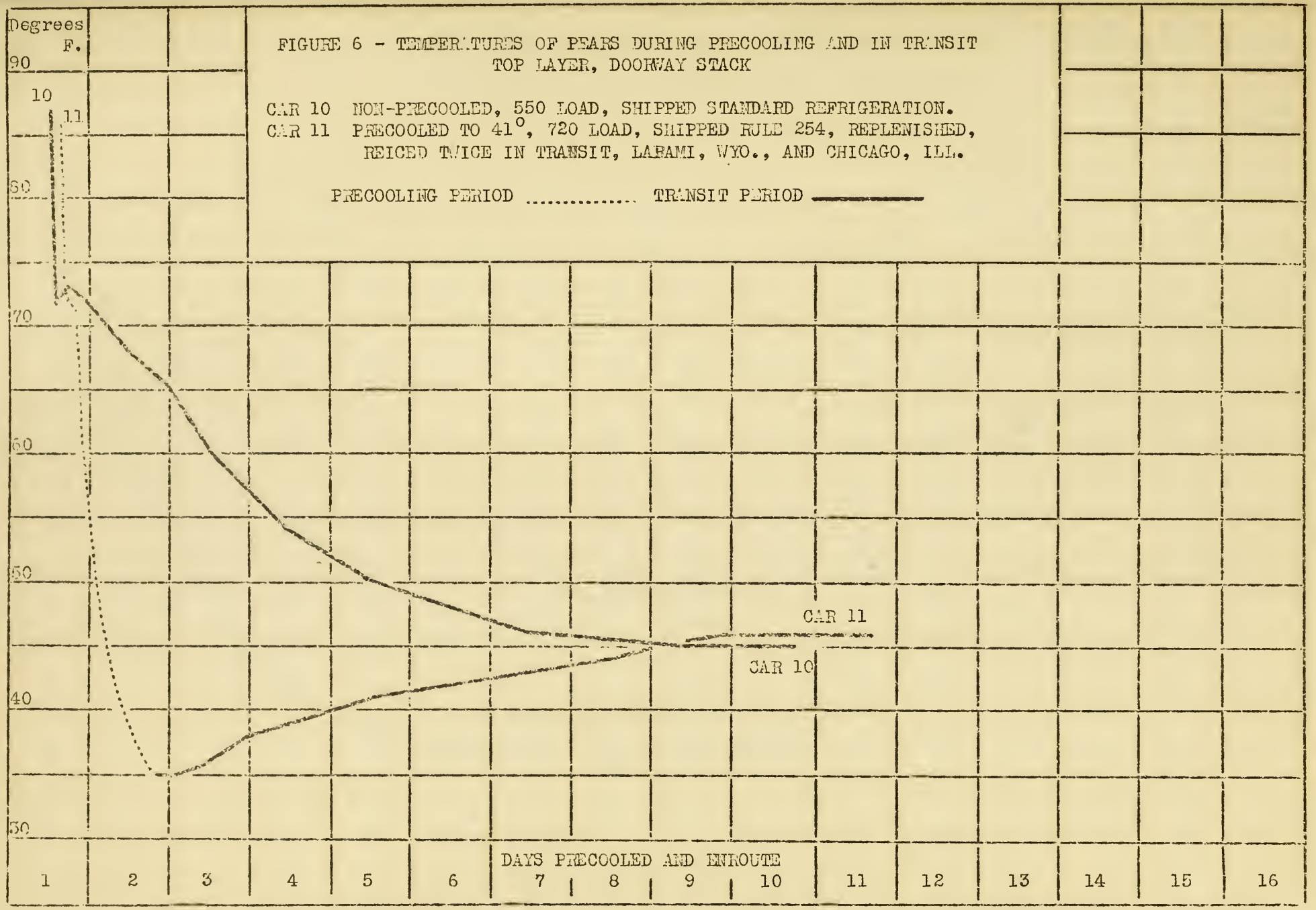
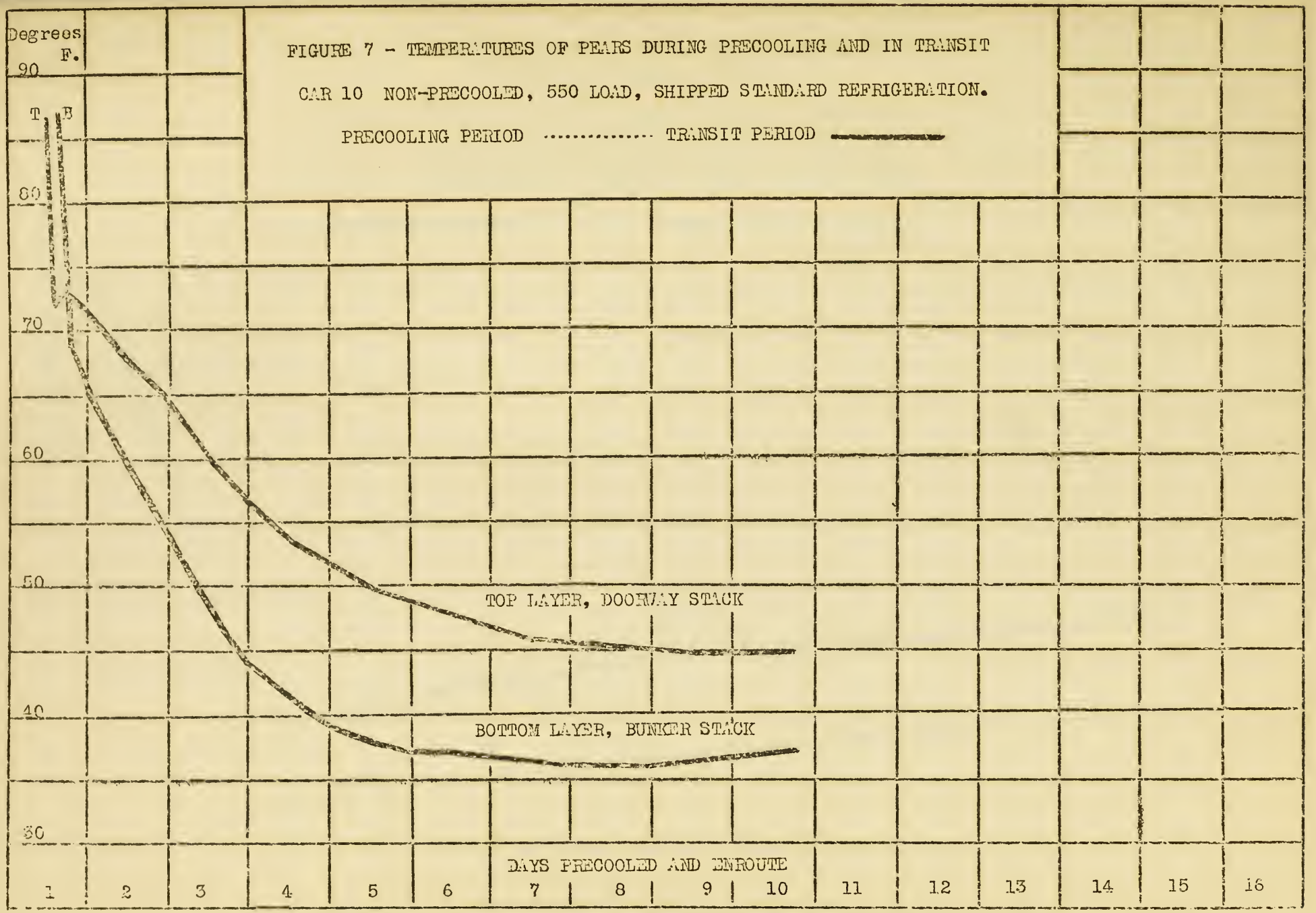


FIGURE 7 - TEMPERATURES OF PEARS DURING PRECOOLING AND IN TRANSIT

CAR 10 NON-PRECOOLED, 550 LOAD, SHIPPED STANDARD REFRIGERATION.

PRECOOLING PERIOD ..... TRANSIT PERIOD ———



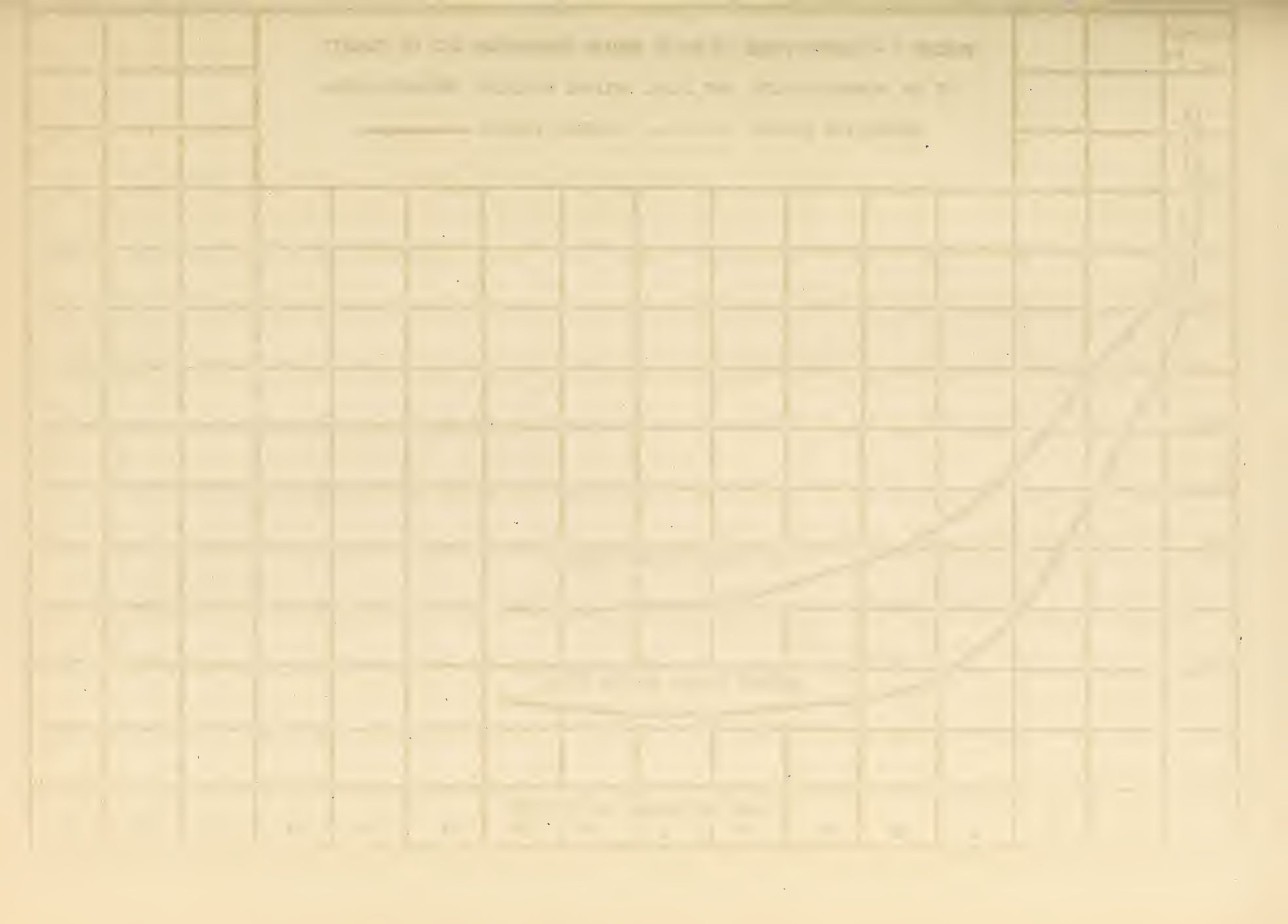
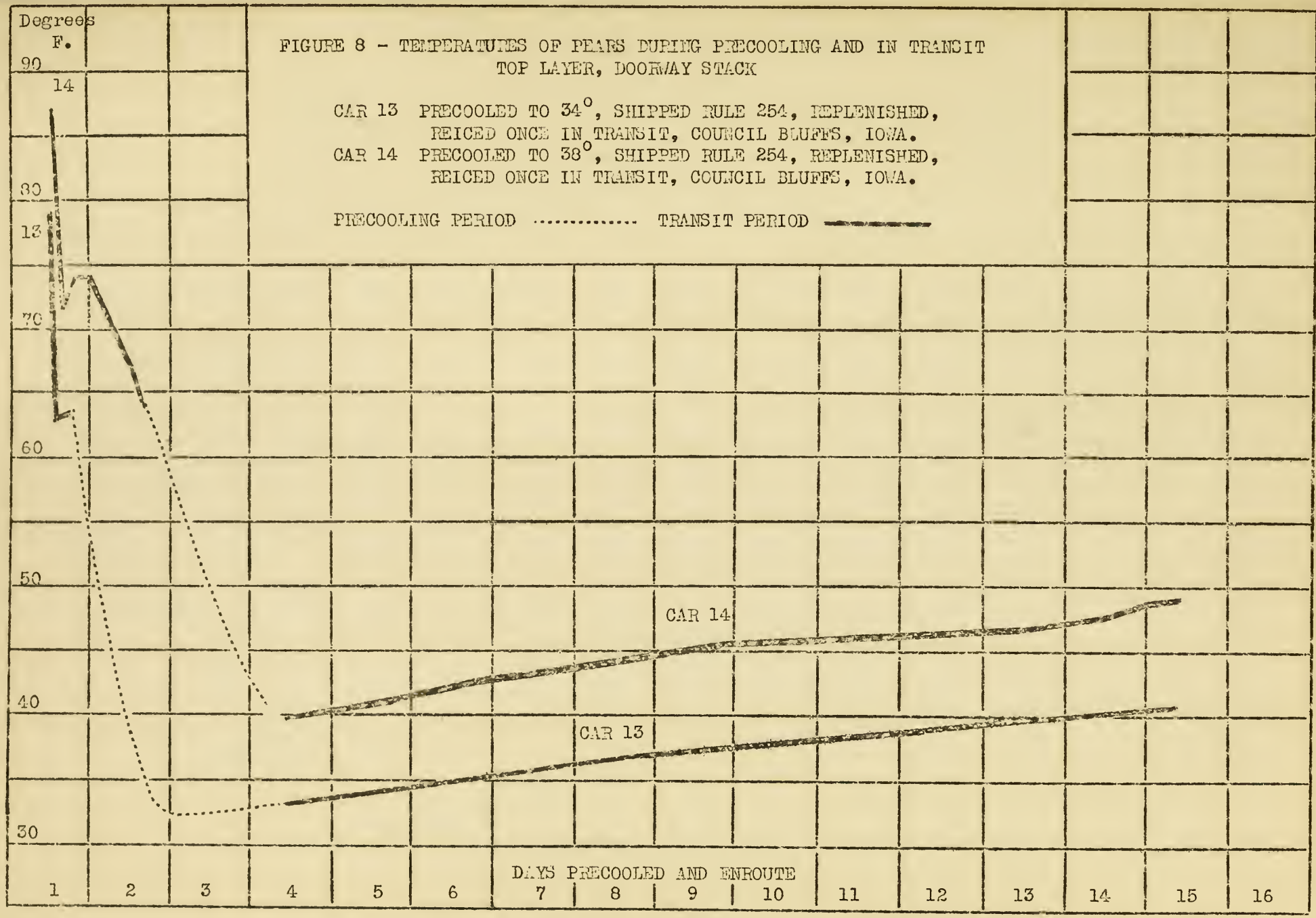
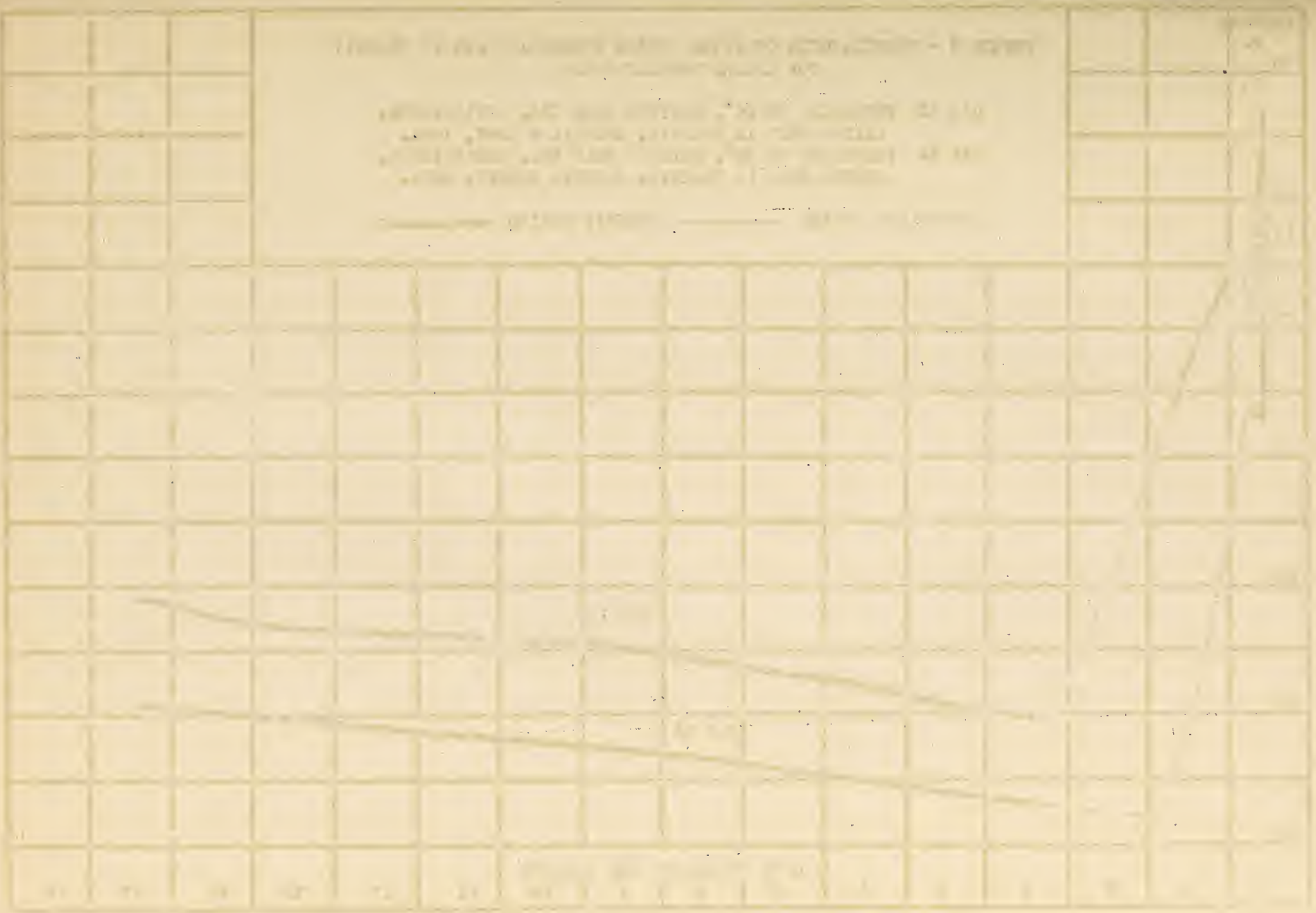


FIGURE 8 - TEMPERATURES OF PEARS DURING PRECOOLING AND IN TRANSIT
TOP LAYER, DOORWAY STACK

CAR 13 PRECOOLED TO 34°, SHIPPED RULE 254, REPLENISHED, REICED ONCE IN TRANSIT, COUNCIL BLUFFS, IOWA.
CAR 14 PRECOOLED TO 38°, SHIPPED RULE 254, REPLENISHED, REICED ONCE IN TRANSIT, COUNCIL BLUFFS, IOWA.

PRECOOLING PERIOD ..... TRANSIT PERIOD ———





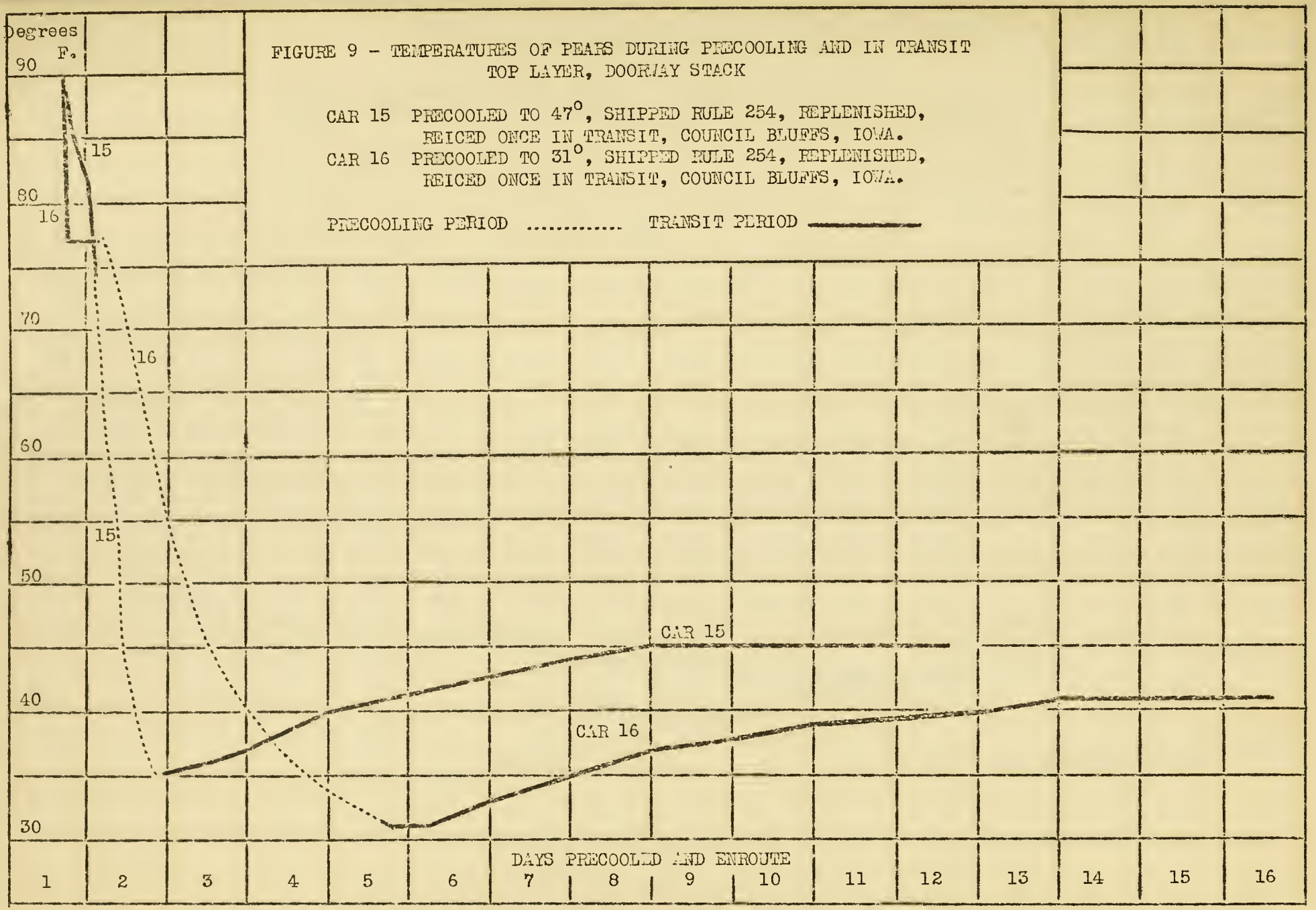


FIGURE 9 - TEMPERATURES OF PEARS DURING PRECOOLING AND IN TRANSIT
TOP LAYER, DOORWAY STACK

CAR 15 PRECOOLED TO 47°, SHIPPED RULE 254, REPLENISHED,
REICED ONCE IN TRANSIT, COUNCIL BLUFFS, IOWA.
CAR 16 PRECOOLED TO 31°, SHIPPED RULE 254, REPLENISHED,
REICED ONCE IN TRANSIT, COUNCIL BLUFFS, IOWA.

PRECOOLING PERIOD ..... TRANSIT PERIOD ———

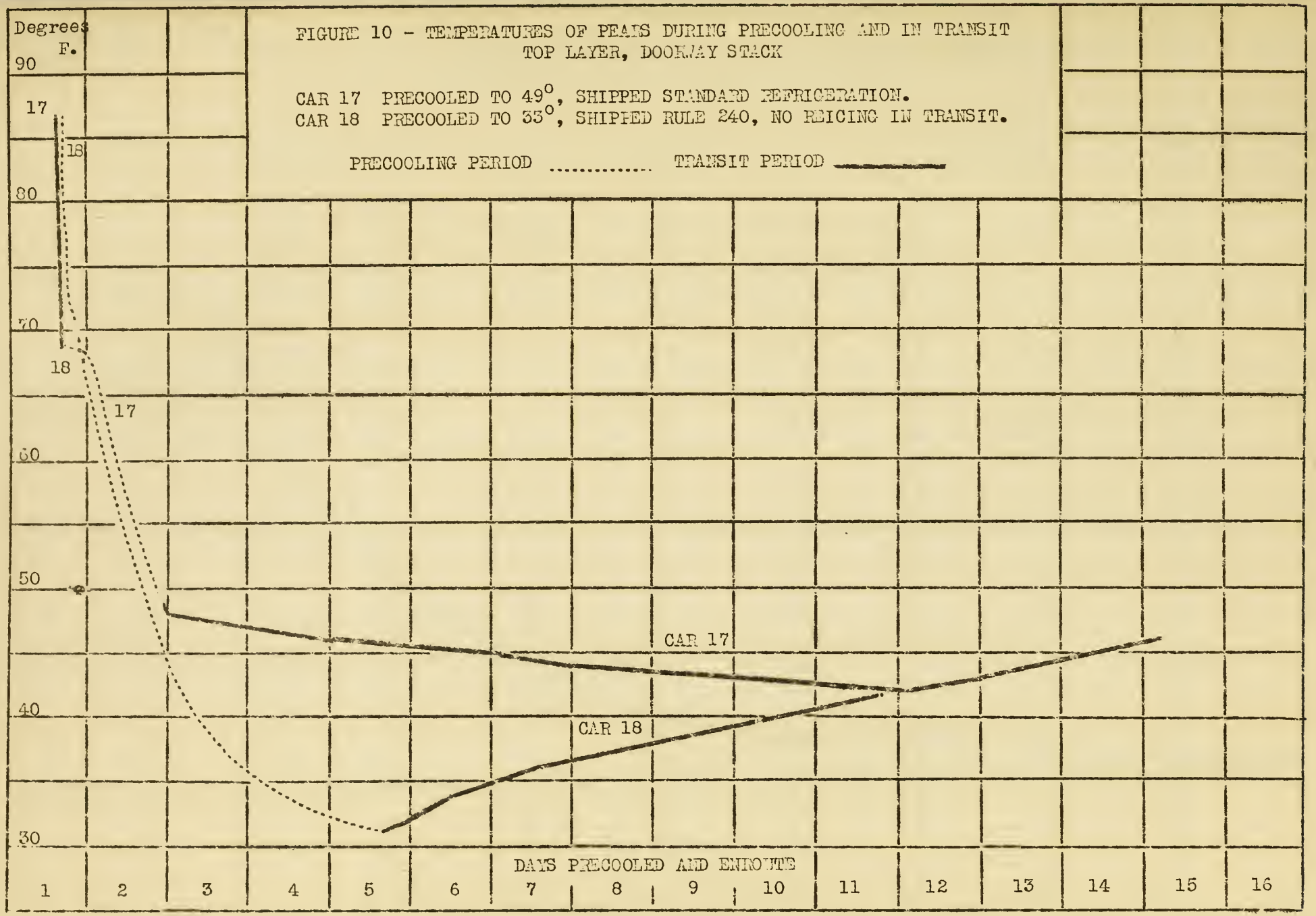


FIGURE 10 - TEMPERATURES OF PEARS DURING PRECOOLING AND IN TRANSIT
TOP LAYER, DOORWAY STACK

CAR 17 PRECOOLED TO 49°, SHIPPED STANDARD REFRIGERATION.
CAR 18 PRECOOLED TO 33°, SHIPPED RULE 240, NO REICING IN TRANSIT.

PRECOOLING PERIOD ..... TRANSIT PERIOD ———

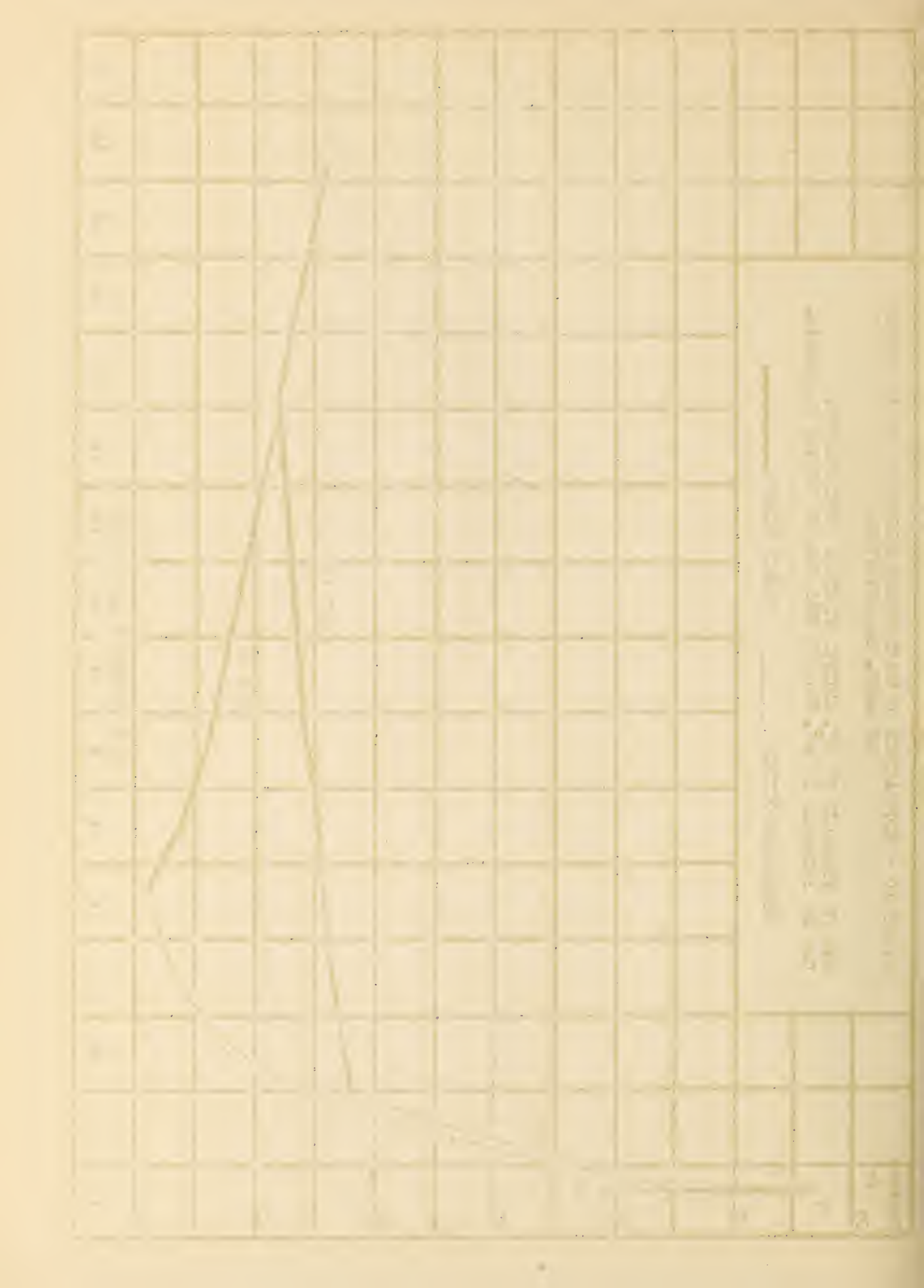
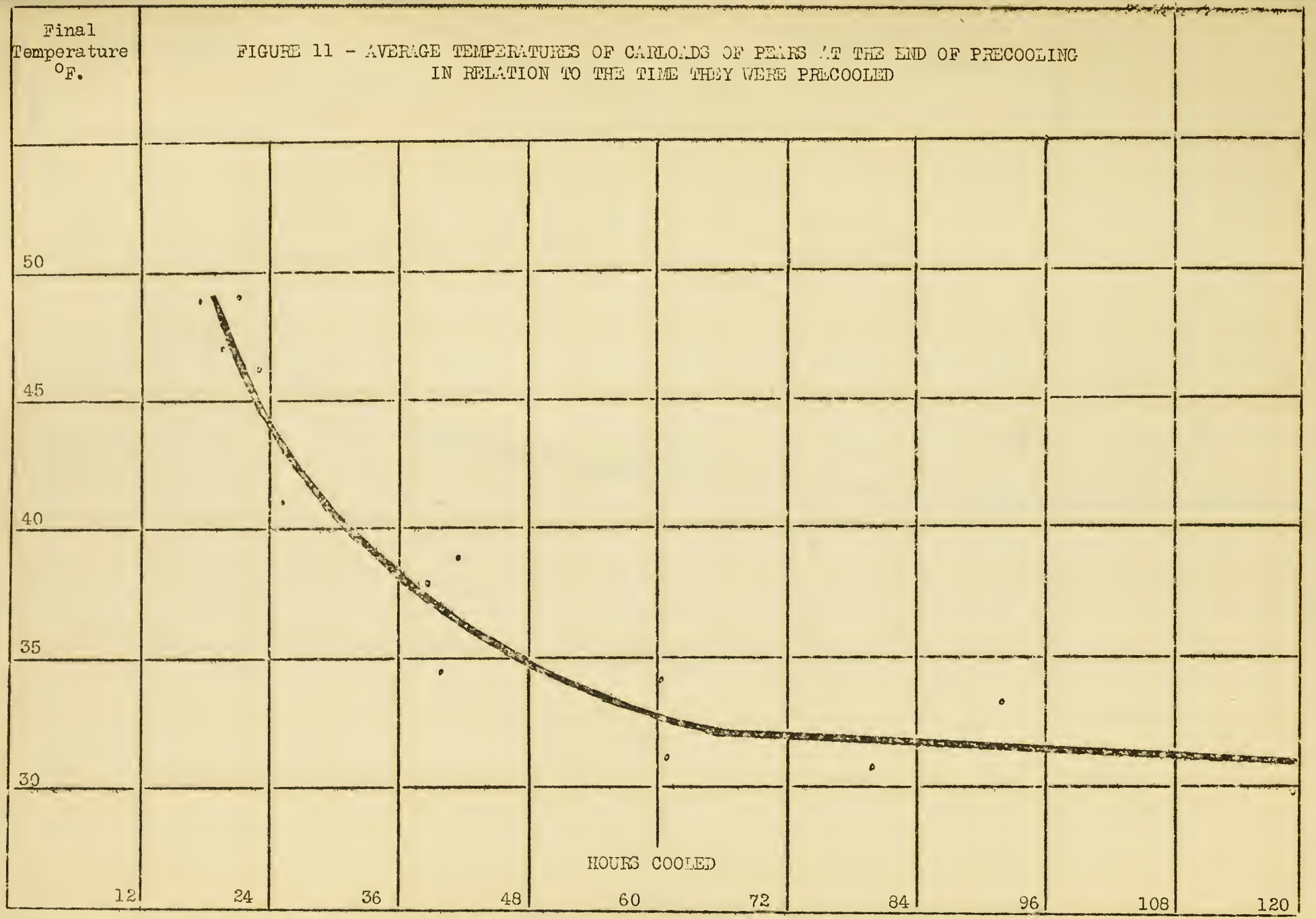


FIGURE 11 - AVERAGE TEMPERATURES OF CARLOADS OF PEARS AT THE END OF PRECOOLING IN RELATION TO THE TIME THEY WERE PRECOOLED



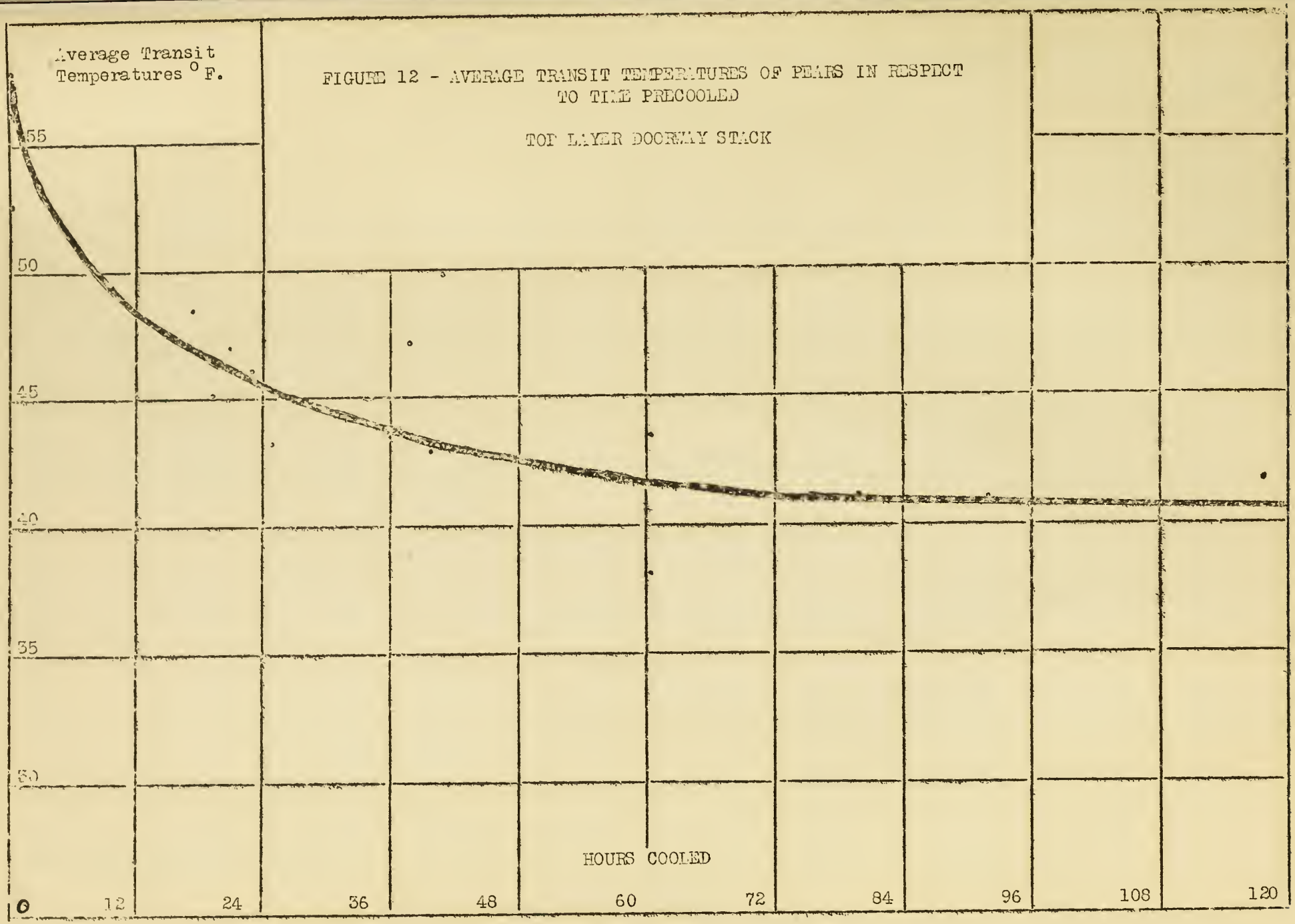


FIGURE 12 - AVERAGE TRANSIT TEMPERATURES OF PEARS IN RESPECT TO TIME PRECOOLED

TOP LAYER DOORWAY STACK

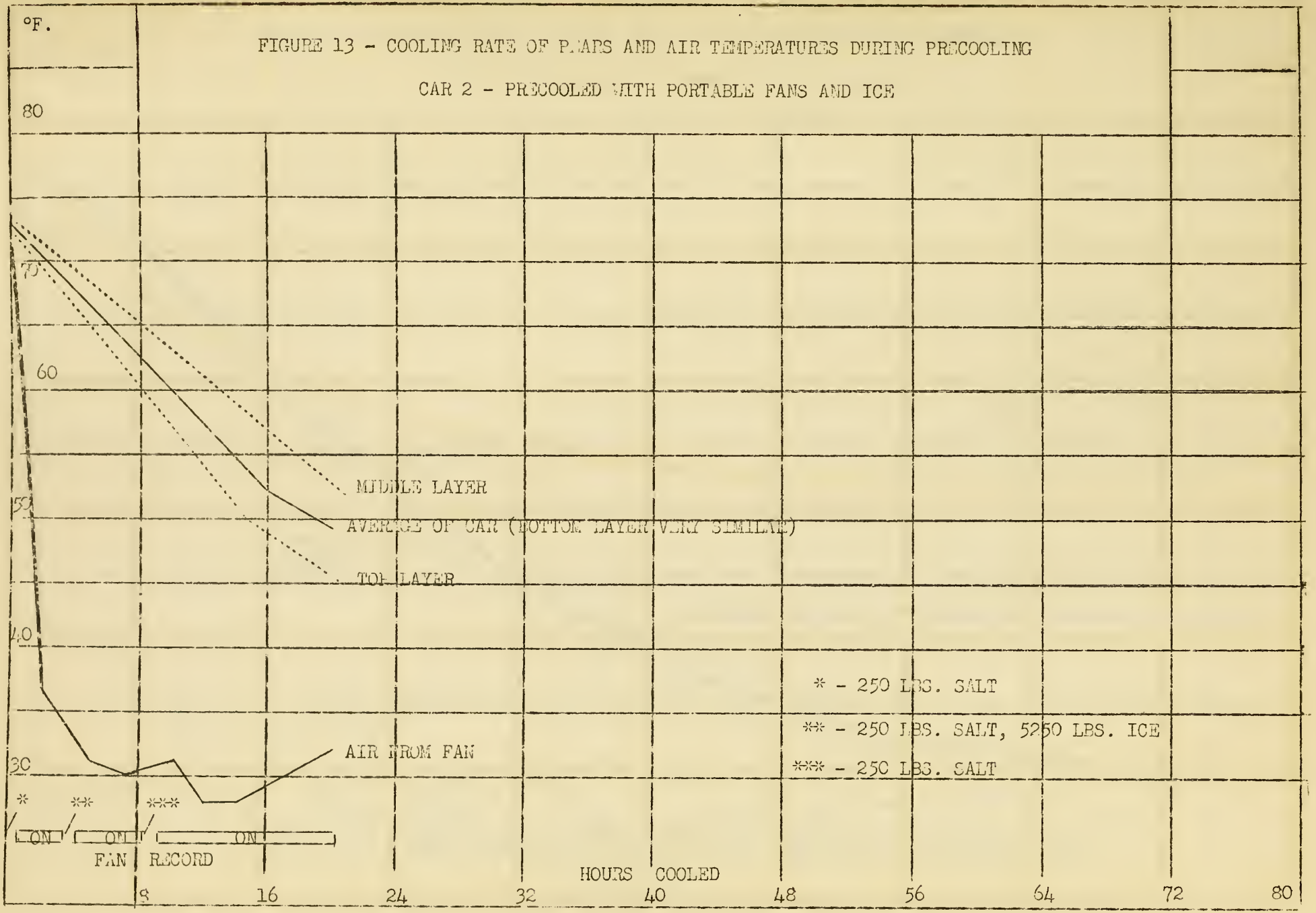
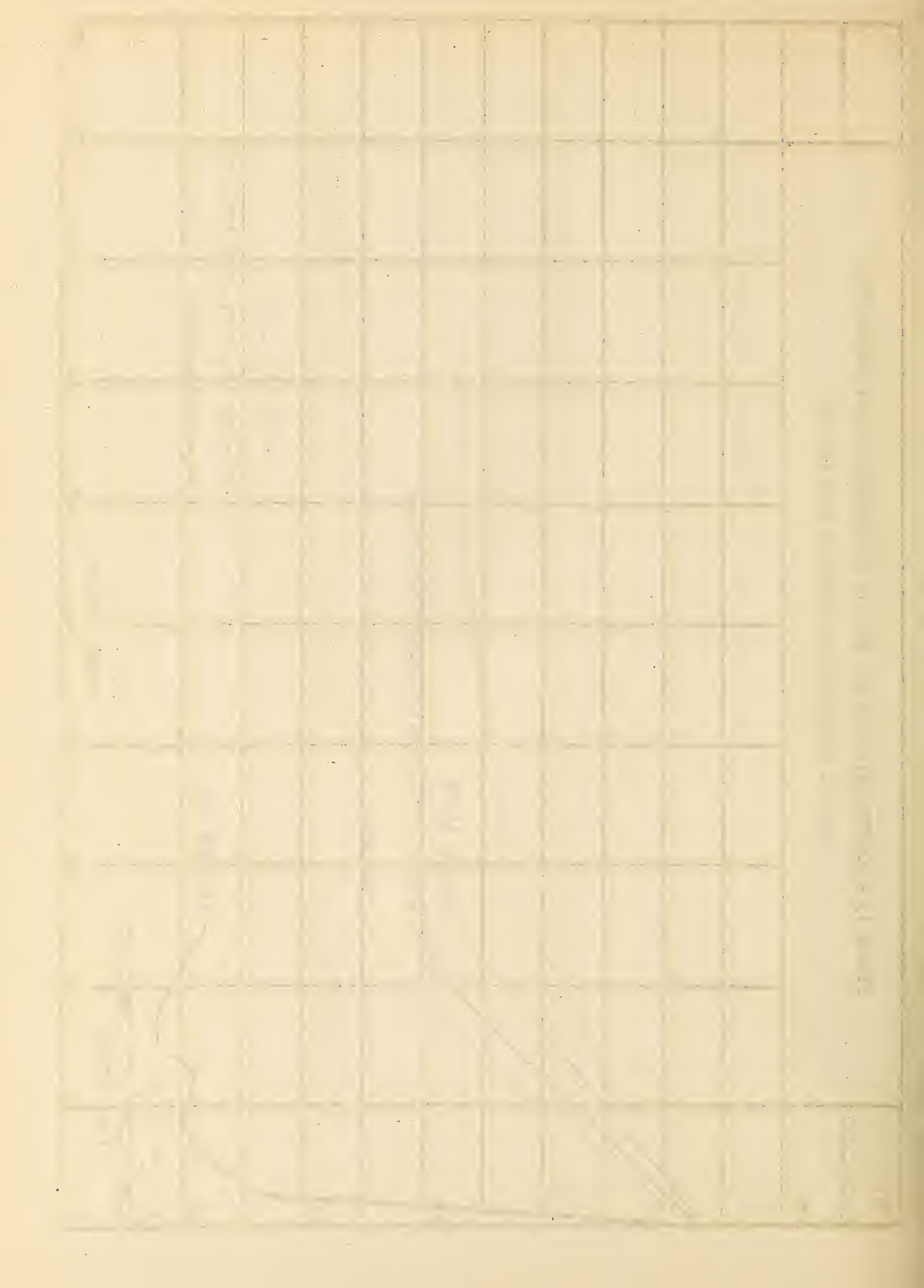
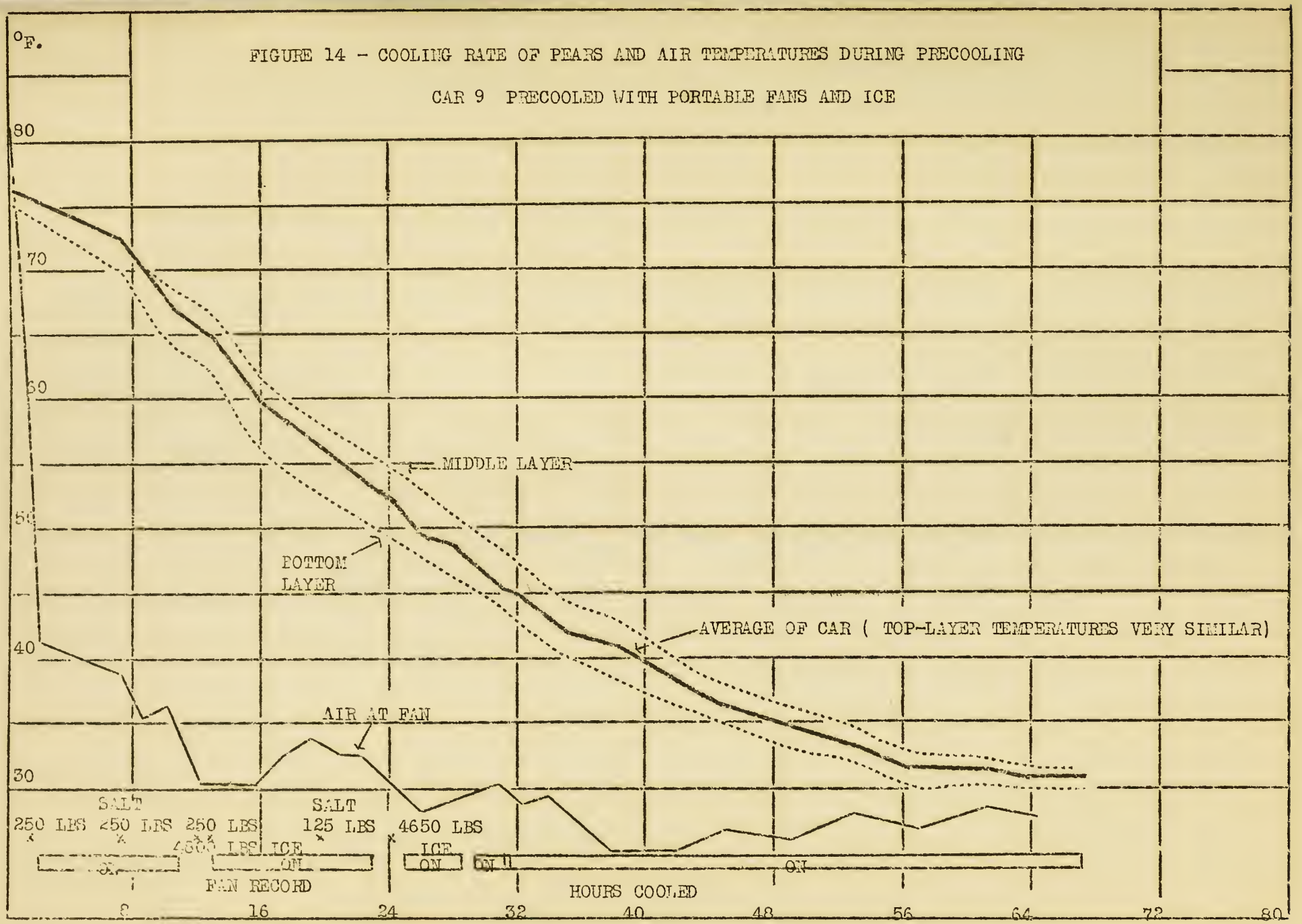


FIGURE 13 - COOLING RATE OF PLATES AND AIR TEMPERATURES DURING PRECOOLING

CAR 2 - PRECOOLED WITH PORTABLE FANS AND ICE




°F.
FIGURE 14 - COOLING RATE OF PEARS AND AIR TEMPERATURES DURING PRECOOLING
CAR 9 PRECOOLED WITH PORTABLE FANS AND ICE
80
70
60
50
40
30
MIDDLE LAYER
BOTTOM LAYER
AVERAGE OF CAR (TOP-LAYER TEMPERATURES VERY SIMILAR)
AIR AT FAN
SALT 250 LBS
SALT 250 LBS
250 LBS
4650 LBS ICE
SALT 125 LBS
4650 LBS
ICE ON
ICE ON
ON
ON
FAN RECORD
HOURS COOLED
8
16
24
32
40
48
56
64
72
80

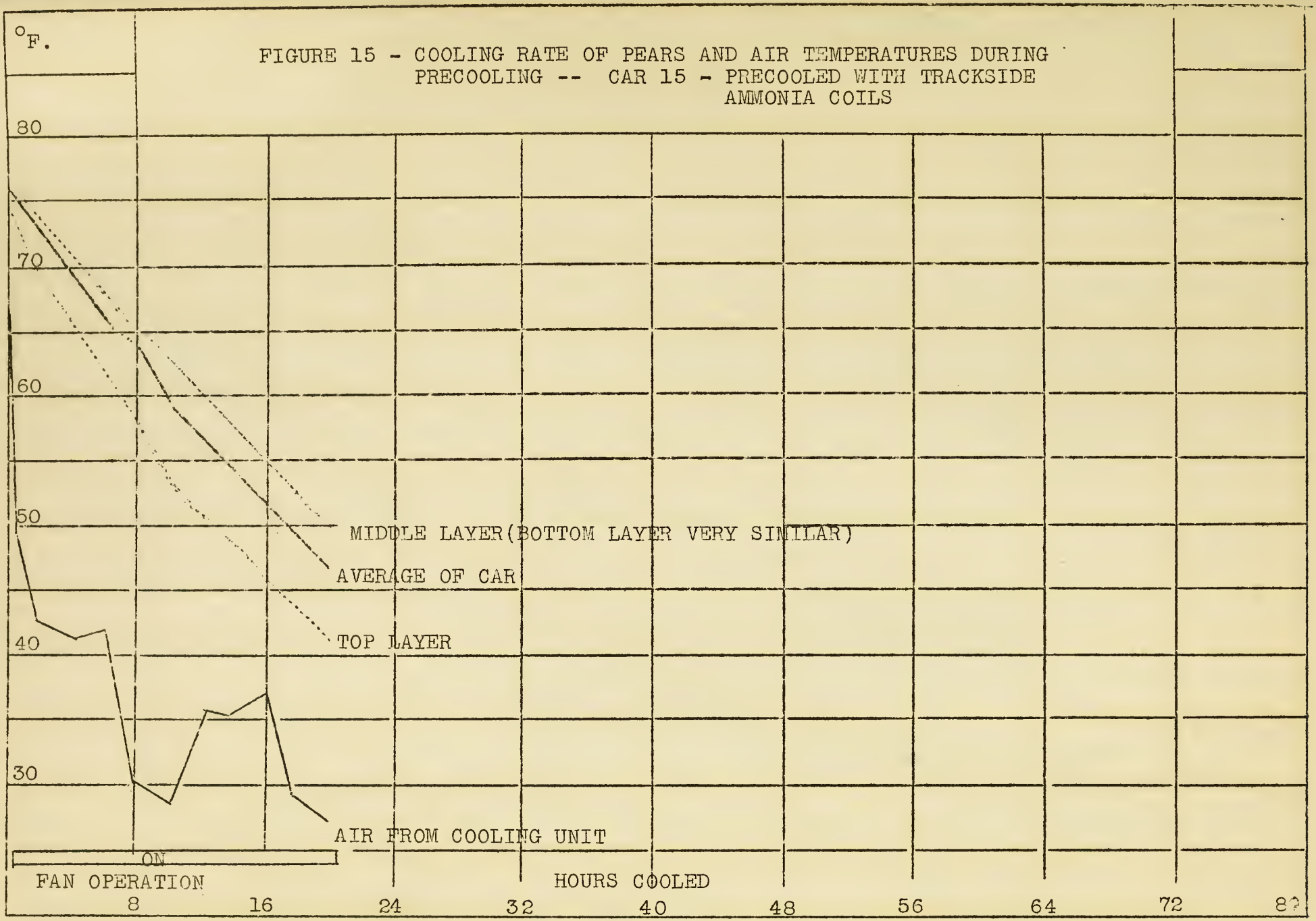
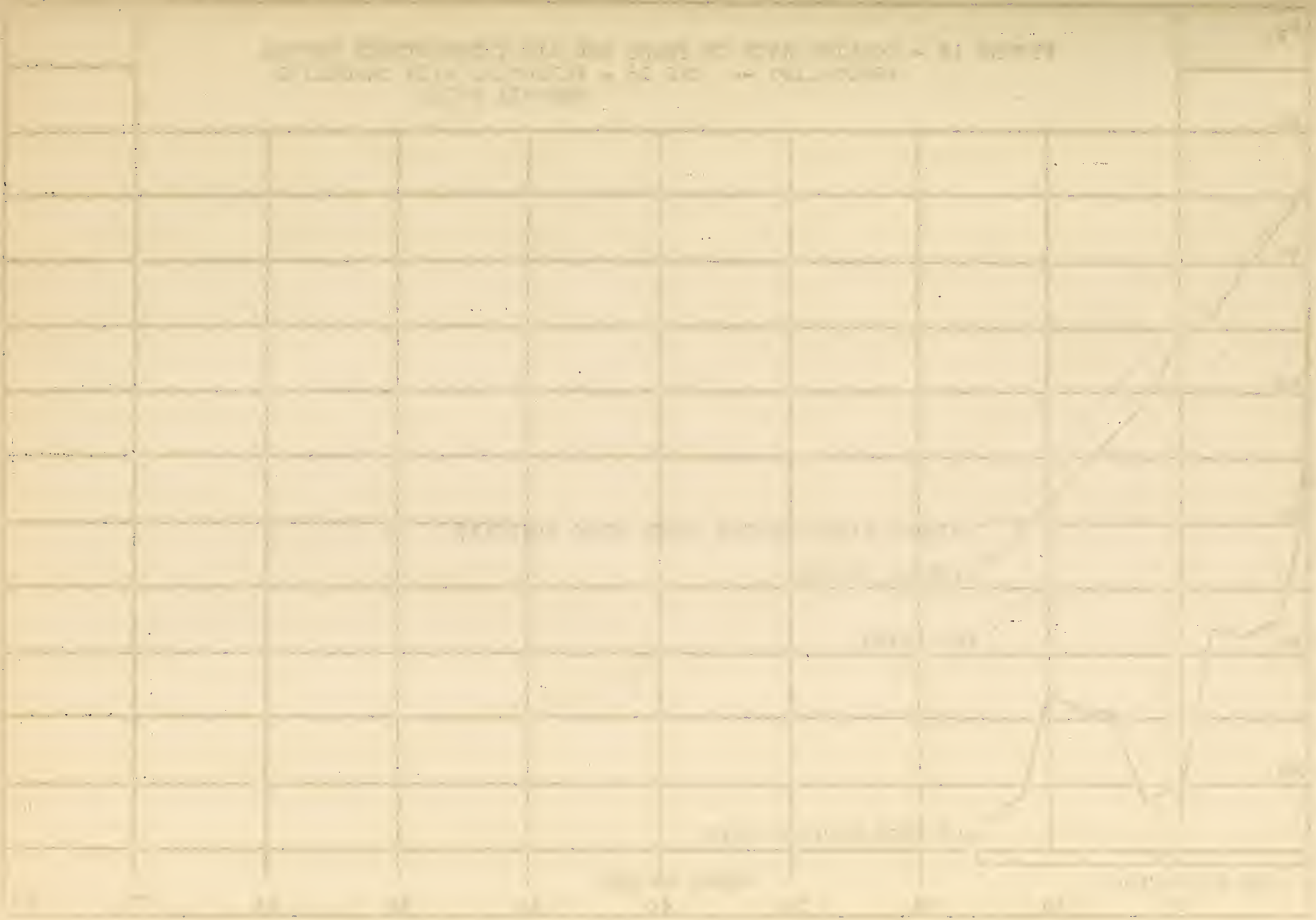


FIGURE 15 - COOLING RATE OF PEARS AND AIR TEMPERATURES DURING PRECOOLING -- CAR 15 - PRECOOLED WITH TRACKSIDE AMMONIA COILS



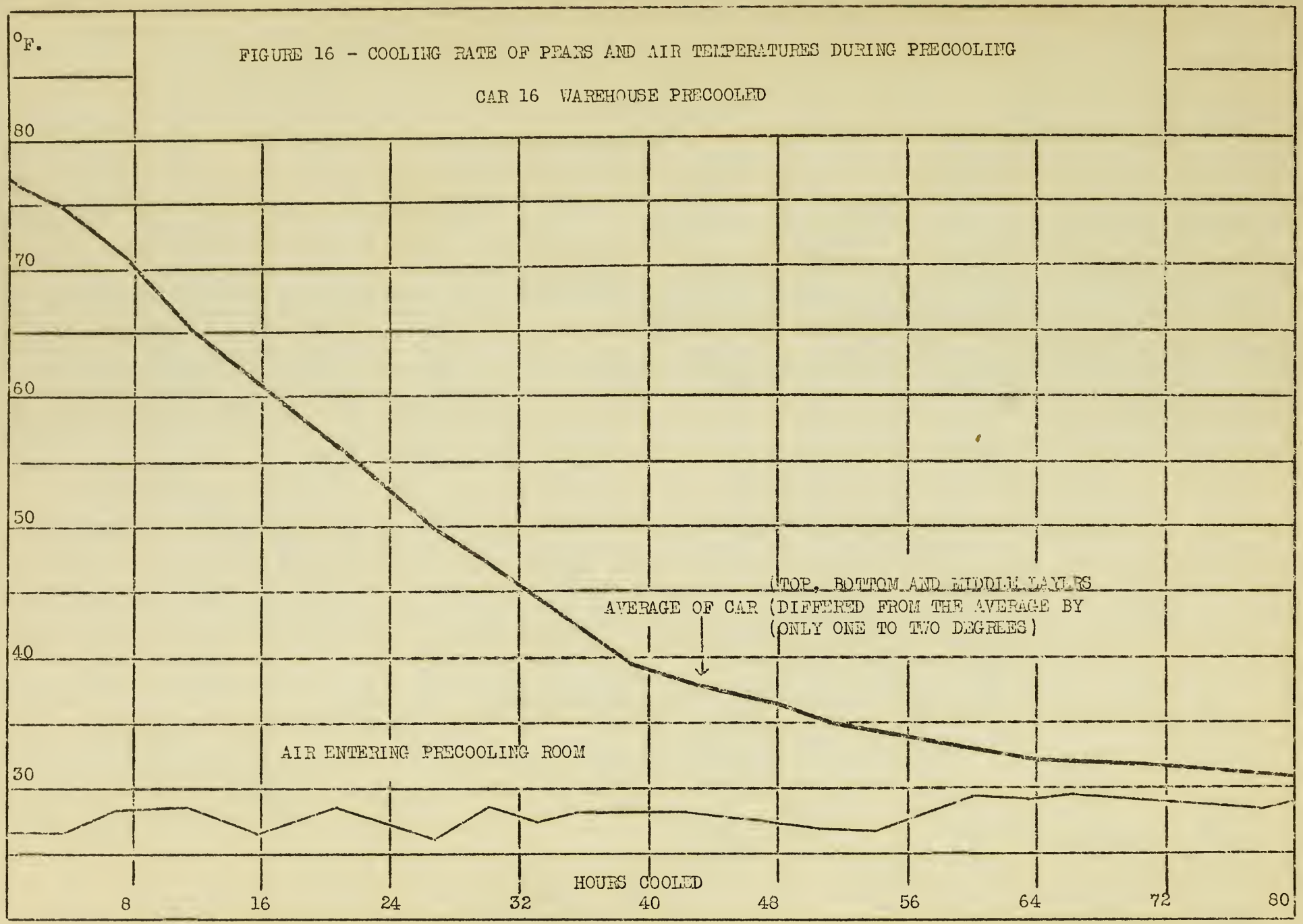


FIGURE 16 - COOLING RATE OF PEARS AND AIR TEMPERATURES DURING PRECOOLING

CAR 16 WAREHOUSE PRECOOLED